Acc. No .. ..

ISSUE LABEL

Not later the latest date stamped below.

THE TECHNIQUE OF MOTION PICTURE PRODUCTION

THE TECHNIQUE OF MOTION PICTURE PRODUCTION

A Symposium of Papers Presented at the 51st Semi-Annual Convention of the Society of Motion Picture Engineers, Hollywood, California

Published 1944
for the SOCIETY OF MOTION PICTURE ENGINEERS
by
INTERSCIENCE PUBLISHERS, INC.
NEW YORK, N. Y.

Distributors: INTERSCIENCE PUBLISHERS, INC
215 Fourth Avenue, New York 3, N. Y.

Printed in the United States of America

PREFACE

At the Spring 1942 Technical Conference of the Society of Motion Picture Engineers in Hollywood, California, a symposium was presented covering the current technical practices in the motion picture industry as applied to actual motion picture production. While information with regard to many of the subjects treated is scattered through the literature, no such complete descriptions of the various techniques involved had hitherto been assembled in such a logical, convenient, and highly educational sequence. The program was received with such acclaim by the audiences in attendance that the Board of Governors of the Society authorized the publication of these papers in book form, after their publication in the *Journal of the Society of Motion Picture Engineers.*

The papers of the symposium are presented here in the general order of the steps taken in the production and presentation of motion pictures in the studios, laboratories, and theaters. Each section has been prepared by a man well fitted by his knowledge and experience in a particular field to give authentic information on the various problems arising in the manufacture of this great entertainment and educational medium.

It is the hope of the Society that this book will prove a useful and valuable guide to the general solution of the many problems which characterize the motion picture industry, in particular as these problems may be encountered in the postwar period of re-establishment and expansion throughout the world.

LIST OF CONTRIBUTORS

Leon S. Becker, Warner Bros Pictures, Inc , Burbank, Calif *Technology* (pp 1–10). Source:* Vol. XXXIX, pp. 109–118, August, 1942.

John W. Boyle, Universal Pictures Co., Inc., Universal City, Calif *Black and White Cinematography* (pp 11–19) Source· Vol. XXXIX, pp 83–92, August, 1942.

Bernard B. Brown, Universal Pictures Co., Inc., Universal City, Calif. *Prescoring and Scoring* (pp 65–68). Source: Vol. XXXIX, pp 228 231, October, 1942.

Charles G. Clarke, Twentieth Century-Fox Film Corp , Beverly Hills, Calif *Clouds in Exterior Scenes* (pp 20–23). Source: Vol XXXIX, pp 92–96, August, 1942.

Farciot Edouart, Paramount Pictures, Inc , Hollywood, Calif *Paramount Projection Equipment* (pp. 104–109). Source: Vol XL, pp. 368–373, June, 1943

L. T. Goldsmith, Warner Bros. Pictures, Inc , Burbank, Calif *Re-Recording* (pp. 43–49). Source: Vol XXXIX, pp 277–283, November, 1942.

C. W. Handley, National Carbon Co , Los Angeles, Calif. (With R G Linderman and A. Rodgers) *Illumination* (pp 69–103). Source· Vol XL, pp 333 367, June, 1943

Winton Hoch, Technicolor Motion Picture Corp , Hollywood, Calif *Technicolor Cinematography* (pp 24–36) Source Vol XXXIX, pp 96-108, August, 1942

R. G. Linderman, Mole-Richardson Co , Hollywood, Calif (With C W Handley and A Rodgers) *Illumination* (pp. 69–103) Source: Vol XL, pp. 333-367, June, 1943.

A. Rodgers, General Electric Co , Los Angeles, Calif (With R G Linderman and C W. Handley) *Illumination* (pp 69 103) Source· Vol XL, pp. 333–367, June, 1943.

Fred M. Sersen, Twentieth Century-Fox Film Corp , Beverly Hills, Calif. *Special Photographic Effects* (pp 37–42). Source· Vol XL, pp 374-379, June, 1943

Fredrick Y. Smith, Metro-Goldwyn-Mayer Studios, Culver City, Calif *Cutting and Editing* (pp 130–139). Source· Vol XXXIX, pp 284-293, November, 1942.

Herbert A. Starke, RKO Service Corp , Hollywood, Calif *Projection* (pp. 140–146). Source: Vol. XLI, pp. 183–189, August, 1943

Homer G. Tasker, Paramount Pictures, Inc., Hollywood, Calif *Sound Recording* (pp. 50–64). Source: Vol XXXIX, pp 213–227, October, 1942

James R. Wilkinson, Paramount Pictures, Inc., Hollywood, Calif. *Laboratory Practices* (pp. 110–129). Source: Vol. XXXIX, pp. 166–185, September, 1942.

---

* All sources refer to the *Journal of the Society of Motion Picture Engineers*

CONTENTS

TECHNOLOGY IN THE ART OF PRODUCING MOTION PICTURES

LEON S. BECKER

Summary. *The motion picture and the automobile were born at the turn of the century and grew up together. Both have their foundations in science and technology, and both have profoundly affected our individual and national lives. Their maturity has placed them among the five largest American industries, yet one is fundamentally an art. An automobile is something concrete, tangible, something real; a motion picture is light and shadow, laughter and tears, speech and music. The motion picture is an art as well as an industry. The motivating forces of the film are drama, comedy, human experience — yet it could not exist except for the organized efforts of the many craftsmen and technicians that make it an industry. Since art and industry are so interwoven, a change in technology affects the art of the film, while the demands of the art bring about technical improvements.*

This report illustrates the role that technology plays in the conception of the film as an art, and the changes that the demands of the art itself have brought about in technic. The cameraman's universal focus, the soundman's reverberation chamber, the set designer's cloth ceiling—all have their share in telling a story realistically and dramatically. Someone's story idea sets this intricate machinery in motion, and from the writer, actor, artist, and engineer comes a living entity—a combination of arts that have been in development since man first learned to record his experiences for posterity.

When we go to the theater to see a motion picture, we usually go because we want to be entertained. We like to feel the presence of other human beings around us, because we are gregarious; and we want to know about their experiences, because we are curious. If the experiences of the characters on the screen are colorful and told well, we like the picture and call it entertaining; we recommend it to our friends. If the characters are colorless and inconsistent, either because of poor acting or poor story, we say that the picture is dull; we do not recommend it to our friends.

Our reaction to a picture is determined by its realism and its dramatic content. The index of realism is dependent upon how

closely the experiences of the characters in the story coincide with our own, or how closely they approach our own ideas of what those experiences would be in a similar circumstance. A picture about colonial days, for example, can not be made using the speech idioms or specific behavior of the people of that time, since our ideas of their behavior are in terms of today—how we would act in the clothes, carriages, houses of that century. In other words, for realism, accurate physical environment in terms of the material things of everyday living is necessary, but the psychological processes must be in those terms we understand today.

The index of dramatic content depends upon the story material and continuity, the choice of dramatized incidents, camera work, editing, sound-effects, music, acting, direction, and numerous other elements. A picture about the Civil War may have an extremely accurate reproduction of the battle between the Monitor and the Merrimac down to the last rivet. But unless that battle has drama for the purposes of the story, adequate acting and direction, and comparable quality in the other elements, its dramatic content in terms of the film as a whole will be practically nil.

The industry has achieved a notably high standard of realism from the standpoint of set design, costuming, research, and the things concerned with the physical environment of the dramatized story. Sound, lighting, make-up, camera, miniature work, process shots, are technically adequate and consistently dependable. But it is in the application of the technical instruments for the purposes of telling a story dramatically and colorfully that the variation in product occurs, and that we, as technicians, should attempt to clarify for ourselves and for the benefit of the industry. The field is obviously vast in scope, and would require the collaboration of many specialists to cover the subject adequately. The writer's particular work is in sound. Therefore this paper, which attempts to explore the region between the purely technical and the artistic, where the technician's knowledge of his tools and his individuality and imagination make the difference between an outstanding production and just another adequate picture, is written from that point of view.

The story of the motion picture industry as an art is one of continual growth and development from the time that Muybridge, in 1878, took a series of consecutive pictures to study the motion of a horse. The purpose was scientific, but the entertainment possibilities were quickly recognized. Pioneers built crude cameras of various

shapes and sizes, experimented with film of varying dimensions and light-sensitive coatings, and photographed anything in motion. The first films had nothing more than side-show value, and pictures of any moving objects were sufficient to gain an audience. A moving train, a falling building, a bicycle rider, were all adequate subjects for the very short films of that day. The possibilities of the film as a story-telling medium were not long overlooked, however, and as early as 1898 a series of shots were spliced together to form a continuous story.

It was not long before the producers of those days recognized that this new medium, the moving picture, would revolutionize the art of story-telling. The new freedom in space and time opened up unlimited story possibilities. The film could transport the audience within a fraction of a second from the equator to the pole, from the highest mountain peak to the most arid desert. The physical restrictions of the stage upon action and story locale were shattered. Because of the new freedom in space and time, the early film stories were built around physical spectacles, such as forest fires, train wrecks, or crumbling bridges, that could never have been reproduced satisfactorily on the stage. Now, for the first time in human experience, the whole world was truly a stage.

The characters in the first films were "black-and-white" types; the hero was handsome, strong, and silent, the heroine pure and feminine, the villain mustached and vile. There was no real delineation of character, for we must remember that the acting technic was directly related to the stage of that time, when the melodrama was popular. The physical limitations of the stage, the poor lighting, and the distance of the actor from the audience necessitated broad gestures and easily recognizable heroes and villains.

The mobility of the new camera-eye quickly wrought a change in acting technic, however. Since the camera and projector could magnify the image on the screen to many times its normal size and bring the character that much closer to the audience, the broad, sweeping gestures of the stage actor had to be subdued in order to be credible. This modification in acting technic was so rapid that after a decade of development the exaggerated motions of even the greatest of the stage stars, when transposed to celluloid, appeared as ridiculous to the audiences of the silent days as the early silent pictures appear to us now. In 1912, a picture starring the great French actress Sarah Bernhardt was released in this country, and was laughed off the screen. She had used her stage technic for the film.

In only a few years, therefore, the motion picture had severed many of its ties with its parent, the stage. In fact, it was such a lusty, self-willed fellow that it succeeded in changing the ways of its parent. The appetite of this voracious youngster for greater screen illumination improved stage lighting, and the comparative richness of screen sets influenced stage scenery and props. Because of the competition, stage playwrights had to place greater emphasis upon delineation of character through dialog, which the screen was unable to do because it had not yet learned to speak. Conversely, the film writer concentrated upon stories of action rather than of character.

But the complementary element in dramatic story-telling was still lacking in the motion picture — sound, or rather, synchronized sound. The dramatic need for sound was so strongly felt in the silent days that directors like D. W. Griffith and von Stroheim suggested sound by means of pictures and titles, and even made the actors speak their lines for greater realism, though not a syllable came from the screen. A title, such as "the sound of the surf told them the sea was near," or a picture close-up of a dog howling at the grave of its master, were used to give the film more realism and dramatic enhancement. Even lapse of time was measured by "pictorial sound" suggestion — a milk-wagon clattering on the cobblestones to indicate the arrival of morning, or a dissolve to the pendulum of a clock to suggest the passage of time. And, of course, we remember how music and even sound-effects were invariably an accompaniment for the old silents, either by a tinny piano, a wheezy organ, or in the case of the first-run movie palaces, by a 20-piece orchestra with a specially composed score. It was recognized, therefore, long before the synchronized sound-track, that since sound and sight together were closer to human experience, a motion picture plus music or sound suggestion would be more realistic — hence more dramatic.

The birth of the sound-film stimulated technical progress to an amazing degree and resulted in standardizations that proved of great benefit to the industry. The speed of the projected film was fixed at 90 feet a minute for the reason that the high frequency voice sounds, which give to speech intelligibility and to music its timbre and brilliance, could not be recorded at a slower rate and still retain their definition. For sound-track development purposes film emulsion had to be made more uniform, which not only resulted in more consistent sound, but in a better picture as well. The camera, though shackled at first by the unwieldy booths and blimps, quickly regained

its mobility and even became more articulate. Set lighting was forced to go to the incandescent lamp, because the arc light was too noisy for the microphone, and the whole problem of lighting was revolutionized. Set design, film processing, stage construction, and even make-up were benefited by the new addition to the art.

But as impressive as the technical advances were, the implications and possibilities of the enhanced medium as a record and interpretation of life were even more imposing. Here, at last, man had found a means of transposing his experiences into permanence with the greatest realism he had ever known. The art-forms of centuries became available. Both the spoken word and literature were now translatable. Music could heighten the emotional experience to the point of pain. And certainly acting again was profoundly affected to the extent of a redefinition of the art in terms of the sound-film. Gradations of character and naturalness were imperative to the realism of the synthesis of sound and picture.

With the birth of synchronized sound, the spoken word to the actor meant the ability to play a character instead of a type. The close-up of sound as well as of camera made underplaying the rule and overplaying a caricature. Subtle relations could now exist among the characters of a story, and abstract intellectual ideas could be expressed. The possibility of portraying characters instead of types opened up wider vistas of possible screen material. The vast field of human psychology was thrown open to exploration.

When we hear a sound in real life, such as of someone speaking to us, or from a bird in a tree, we can locate the source of the sound because we have binaural perception, two separate ears, each of which transmits its message to the brain independently of the other. If there are two birds in two different trees, we can not only tell them apart, but can also distinguish their locations. When we cover up one ear, we lose the ability to tell the two sounds apart—we put one of our direction-finders out of commission; and we lose also our aural ability to distinguish depth or space, except by loudness. With only the one ear we have monaural perception. Of course, we still have our eyes to provide a sense of depth and space, but a blind man, whose aural sensitivity has been greatly sharpened, can tell the space and even the size of a room by the faintest sounds. He does it by the amount of reflected sound from the walls and ceiling, as compared to the amount of direct sound. Singing in the shower is a popular pastime because the ego is bolstered by the reverberation of the room

and the smoothing out of voice imperfections by the roar of the water.

For the film audience, the source of sound is the loud speaker array behind the screen. The original source of sound was the microphone on the studio stage. Since there were one microphone and one recording channel, the sound, for the audience, is monaural. We can not distinguish movement or position across the screen. But we can create an illusion of movement to or away from the camera, and even the feeling of space and, environment in the picture, by the use of, first, loudness, and, second, reverberation. A scene shot in a tunnel, or in a mediaeval castle, will be realistic only when the ratio of reflected sound to the original sound is high, and we get the feeling of space.

With the two-dimensional camera, which bears the same psychological relation to the eye as monaural sound does to the ear, the illusion of depth can be achieved by the proper use of lighting and contrast, just as by the manipulation of loudness and reverberation with the microphone. And just as the eye can be drawn to particular persons or objects by the adjustment of focal-length, so can the ear be arrested by the intensification of important sounds and the rejection of unimportant ones. If in a scene we wish to draw the attention of the audience to a child's toy in the center of the floor, we can, by employing an appropriate lens, focus sharply on the toy and blur the background. But if we want to draw attention to a music-box, and yet keep the other props in focus at the same time, we can have the music-box play a tune, which will arrest the ear and draw the eye.

The ear, however, is much more imaginative than the eye, and can be used for purposes of suggestion to a much greater extent. The sound of a coloratura soprano gradually becoming a basso conjures up a picture of a phonograph record slowing down, but a visual image of the record slowing down does not define the sound - it might be a symphony or it might be a baby crying. The ear associates more imaginatively than the eye. We hear the sound of crickets and we imagine night; but a picture of a night scene does not necessarily make our brain hear the sound of crickets. We associate the chirping of birds with trees and the country, a siren with an ambulance. The eye will not violate action experience, but varying impressions to the ear will be credible to the brain. The implications of these psychological phenomena for the purposes of the motion picture are tremendous, and have not been fully realized.

In the decade and a half of the sound-film's existence we have learned many things. The writer, actor, and director have developed a mode of approach and a background of technic through experience as have the technicians. It was learned rather early that if the motion picture was to be dramatic and realistic, the technical elements that go into its creation should be so utilized that they return into oblivion as they do their work. And, axiomatically, if the film is to be effective as a medium of expression, the elements that go into its creation must merge into the whole. Music, dialog, sound-effects, the camera close-up, pan-focus, acting, set design, lighting, cutting, and so forth can not be utilized alone, but must be used intelligently in conjunction with each other. For the successful synthesis of these elements into an organic whole an analysis of these different elements *in relation to each other* must be made.

The cameraman has a wealth of devices he can use in unfolding the story he is telling in conjunction with the other craftsmen. He can vary the depth of field or the size of the image. He can choose the amount and kind of lighting to be used in a particular scene to create a mood or enhance a character. He can undercrank or overcrank to change the pace. The camera records a two-dimensional picture, yet the cameraman has a three-dimensional point of view. He can shoot an object from below or above, from the back or the side. Through a knowledge of the habits of the eye and of pictorial composition he can draw the attention of the audience to any object he may desire for the purpose of the story. It is obvious, then, that the cameraman must not only be competent technically, but should also be artistically capable. To him, with the director, belongs the responsibility of making the most of the efforts of the scenic artist, prop man, actor, and all the other arts and crafts that go into the preparation of the picture for photographing.

There are, in general, two methods of approach to the problem of presenting a specific scene to an audience through the eye of the camera: the objective and the subjective. The camera may record an incident through the eyes of a fictitious person on the sidelines, or through the eyes of one of the characters. For instance, we are shooting a scene of a delirious person in a hospital bed. To put over the fact that the person is delirious we might show him tossing in his bed, or we might show the doctor questioning the nurse about his chart: this is the objective approach. Or, we might photograph the scene as if through the eyes of the sick man, with the camera going in

and out of focus on the objects in the room as he is supposed to see them in his feverish condition: the subjective approach. The objective method is more generally used since it is more direct and straightforward. The subjective method is employed more rarely, because it usually requires carefully prepared establishing shots to be successful.

The imaginative employment of sound is as unlimited as the angles and shadings of the camera. With the wave-filter and equalizer, dialog may be improved, or purposely distorted to simulate telephone or radio quality. Music can be thinned to give it a feeling of eeriness or distance. The reverberation chamber may give speech the quality of an empty hall or the illusion of a voice from another world, and music a bigness for dramatic emphasis. Varying the speed of the sound-track can make Paul Robeson sound like Minnie Mouse, or a chair squeak sound like the creaking of an old pirate ship. In the re-recording process, the proper balance between music, dialog, and effects can be achieved for maximum enjoyment. Unwanted sounds can be deleted and others added. A dramatic sequence can be enhanced and the emotional experience greatly heightened. A comedy scene can be made more humorous through the imaginative use of sound-effects and music. Just as there are fades and dissolves of the picture image, so can there be fades and dissolves of sound for time-lapse and continuity.

Since the human mind can not concentrate on more than one thing at a time, it is necessary, for greatest dramatic effect, to point up either the visual or the aural element in a scene, but not both simultaneously. In John Ford's classic, *The Informer*, for instance, the tapping of the blind man's cane on the pavement is a beautiful example of the subordination of picture to sound, and the dramatic impact it can have. We are interested in the picture of the cane only for information as to the source of the sound: the important thing is the fear and mounting suspense Gypo feels when he hears the tap of the cane, which to him is the forewarning of doom. In *Algiers*, the scene in which the stool pigeon is killed to the musical background of the player piano is an illustration of sound in a completely subordinate role. The climax of the scene is actually the picture—the close-up reactions of Pepe, members of his gang, and the informer. The piano and dialog create a mood only—no dramatic punch standing alone.

Sometimes the impact of the important element can be accen-

tuated and the pace accelerated through the use of a rhythmic pattern in the subordinate element. Any device that tends to increase the concentration of the eye or the ear for the end in view is legitimate. For example, we may have a scene in the box car of a freight train, showing a man crouched in the corner. The man has committed a crime and is escaping. We are interested in showing his reactions by the use of a camera close-up of his face. The visual element, therefore, is the important one. However, the rhythmic clickety-clack of the wheels on the rails plus music is used to heighten the visual picture of the man's abject fear of being caught.

There are times when a rapid shifting of emphasis from sound to picture to sound can do much toward relieving monotony and building up the pace. A simple example of a plane trying to find the landing field in a fog, with shifting emphasis from close-ups of the frightened passengers to the sound of the plane's motors from the ground, back to the interior of the plane, and so forth, illustrates the point.

Dramatically, one of the unfortunate results of the employment of sound-effects has been its over-use—the cluttering-up of a film with sound-effects because they are suggested by the environment. Psychologically we shut out sounds in real life—then why not in the film? Suppose a scene opens with a mother sewing. She is waiting for her child to come home from school. Initially, we hear the sound of a ticking clock in the corner, the laughter and shouts of children as they dawdle on their way, and the chimes of an ice cream man. The mother knows that her child is among them. Suddenly we hear the screech of brakes and a scream. The mother rushes to the window, the camera panning with her. Now, from the moment she hears the scream, there is no need for the ticking clock and the noises below. Everything suddenly goes dead, except the chimes of the ice cream man.

We achieved two things in this scene with sound: first, the cessation of the natural sounds after the scream pointed up the woman's reactions with picture; and second, increased the dramatic effectiveness by the use of sound contrast in the tinkling chimes. The suspension of background sounds is acceptable, because subjectively it occurs similarly in real life. Sound contrast is an excellent device for sharpening the dramatic content of a scene. In *Dark Victory*, when Bette Davis realizes that she is going blind, we hear the sounds of children playing—an effective use of sound contrast.

Another type of sound contrast that could be used very dramati-

cally is silence. By its very nature, sound-film, with its almost continuous use of either sound-effects, music, or dialog, could use silence as an integral part of the sound technic. Silence could be considered as a sound-effect, and treated as such. A picture produced some years ago employed silence very effectively. A musician is shown in his country cottage composing a symphony. An exterior shot shows a landscape of pouring rain and strong wind, with occasional lightning flashes. The sounds of rain, thunder, and howling wind are heard. The camera moves into the cottage to a close-up of the musician as he works on the score. The sound suddenly goes dead, simultaneously with a picture cut to a face close-up. The manner in which the musician's deafness was put over had a marked effect upon the audience, and illustrated what could be done by treating silence in contrast as a sound-effect.

Sound symbolism has been used effectively in several films either as a time-bridge or as a binding agent between scenes. In *39 Steps*, the landlady finds the body of the dead woman, opens her mouth to scream; out of her mouth comes the sound of a train whistle as the picture dissolves to a train speeding on its way to Scotland. Here sound, in place of the more usual picture, was the binding agent between scenes. Sound can be used in association: toward the end of *Goodbye, Mr. Chips*, we see a close-up of the old professor and hear the sounds of the boys arriving at the beginning of the school year, just as he had heard them many years before. The sounds of the boys are used in association, and recall the professor's youth as an inexperienced school teacher. Sound can be used in anticipation of a dramatic climax: the tapping cane in *The Informer*, or the child murderer in *M*, who whistles five bars of "In the Hall of the Mountain King" each time he is about to commit a crime. Sound can be suggestive: the train whistle in *Vivacious Lady* that goes "woo, woo" at the end of the picture, or when the sound of bells is heard each time Ginger Rogers and Burgess Meredith embrace in *Tom, Dick and Harry*.

Much of the really creative work in the use of sound has been in the cartoon field. The investigations and experiments that Disney and his associates have made with sound-effects and stereophonic sound will someday bear fruit and result in much more colorful and dramatic live-action production. Such devices as the sonovox, as used in Disney's *Dumbo*, and the vocoder, which makes speech artificially, will undoubtedly find their place in telling a motion picture story more dramatically.

CINEMATOGRAPHY IN THE HOLLYWOOD STUDIOS

Summary.—*Current practices in cinematography as followed in the Hollywood studios are described. Some of the subjects covered are camera equipment, set lighting, operation of camera crews, exteriors and use of booster lights, exteriors taken indoors, make-up, diffusion, coated lenses, use of light-meters, color contrast of sets, set and production designs, value of hard light for exteriors and interiors, stand-ins, air photography, matching stock shots, Technicolor and bipack, Kodachrome, and monopack.*

Black and White Cinematography

JOHN W. BOYLE

We have come a long way from the time, some twenty years ago, when one was able to recognize the cameraman by the fact that he wore his cap backward, just as one could tell the director by his puttees. No longer does the producer say, "A rock is a rock; shoot it in Griffith Park." Most of the pictures today are made in the studios or on the back lot, and it is the job of the director of photography to set the mood of the story by lighting the scenes in the proper key and using what photographic effects he can conceive and execute on short notice. Although much time is devoted to the preparation of the story and dialog of a picture, only on rare occasions is sufficient preparation allowed for the technical problems involved in set and location planning. Successful pictures result from the teamwork of the various technical staffs involved, with the purpose of achieving the finest artistic and commercial photographic results on every picture produced, be it a simple "short" or a feature.

On some of the more pretentious productions "production designers" have contributed much to further the artistic photographing of

the picture. These production designers are skilled artists, and are called in well in advance of the actual production. They become familiar with the script, cast, and the amount of money that may be spent on the production, and are able to furnish the director and cameraman with a series of sketches showing what the actual scenes should look like. It is hoped that this kind of preparation will come into general use for all types of pictures.

On this subject, Jack Okey, art director for Alexander Korda's *Jungle Book*, has written the following:

"The present-day motion picture is without question the most complex medium of expression ever devised by man. It is certainly not the brain-child of any one person but rather the sum of many individual contributions. All creative talents are called upon to contribute their efforts, the maker of pictures among them. Nothing can paint a picture of a picture as well as a picture.

"In reality a motion picture is a series of pictures. The man most fitted to create pictures is an artist, with his highly specialized training and talent. A man having the power of visualizing an idea and drawing a picture of it that all may see, certainly has a place in the making of motion pictures.

"If the producer would call upon the artist at the same time he called upon his writer, and would have him prepare preliminary drawings or paintings of the subject in mind, there is little doubt that the sketches would help both the producer and the writer to decide many matters; in fact, the director and the chief cameraman should be included in these early conferences. Often a simple sketch will be of assistance to the writer in showing plainly what might take thousands of words to explain. By predetermining questions in this early stage, many costly delays and disappointments can be avoided. Decisions can be made from the sketches as to the desirable lighting effects, wardrobe, characterization, location, sets, and even the very spirit or mood of the whole production. During the preparation period, the artist can make a series of sketches to act as future reminders of the many discussions taking place at the time. As the script develops, a series of sketches, known as continuity sketches, can be made of the various scenes. They provide advance information, and make it possible for the departments to predetermine their work in an intelligent and artistic manner.

"Often on the set, a man under the excitement and stress of the many responsibilities resting upon him may not be able to recall read-

ily what he had previously decided to do with a certain situation. A quick glance at the sketches will recall the entire scheme to him. The sketches can be referred to in the same way in which the written script is used. Sketches that break up the written scene into long, medium, and close shots can stimulate the creative ability of both director and cameraman. They can be guides to strong, beautiful, dramatic patterns or compositions.

"The arrangement of the characters on the screen in good composition can do much to heighten the story. As one simple, well known example, in a "close-up" of an aggressor the head should be well forward on the picture plane, leaving more space behind the head than in front of it; whereas the close-up of the defendant should show more space in front of the head than behind it. Sketches can convey such things as reminders to all concerned throughout the whole production period.

"The word 'composition' has appeared here several times. It is a word almost impossible to define. There are a few elementary rules to govern the building of a picture, such as rhythm without repetition, the bearing of one thing upon another, the relative influence of lights and darks, but these are so self-evident that the painter does not think of them while he is at work. He attacks his subject with his inherent good taste or talent, composing the drama of the subject and injecting into it as much beauty as he can conceive.

"I do not mean to infer that there have not been many beautiful pictures recorded in the past, becausé there most certainly have. What I mean to point out is an easier and surer way, a method of suggestion and help, a wiser procedure."

The short time allotted in practice to the cinematographer to read the script and prepare for production should be emphasized. It is a common occurrence to finish one picture on a Saturday night and be handed a script for a new picture to start the following Monday morning. The cinematographer must then spend Sunday in acquainting himself with the final version of the script; arriving on the set early Monday morning he finds the painters still painting and the set dressers still at work. However, none of these activities have deterred the "gaffer" or chief electrician from roughing in the lighting and in the placing of the overhead units on scaffolds above the set.

With screen stories today overloaded with dialog, it is important that the picture be kept moving. This calls for much camera move-

ment and the shifting of the cast from one position to another throughout the set. Such camera movements involve much study in lighting and composition, and here again it is only by the complete coördination of all departments concerned that the smooth, finished results one sees on the screen are possible. The "operative" cameraman must know his cue to "pan"; the sound technicians must have their cues and must know when and where to move the microphone without causing shadows; the mixer must know when to change the fader setting; the "grip" must know when and at what speed to "dolly" the camera; the assistant cameraman must be constantly alert and must anticipate each actor's move and keep the lens focused always at the proper distance (most scenes, especially those showing two or more actors in the scene, are shot at "split focus," and since the actors do not always keep to their marks on the floor, the assistant must use his judgment). Other members of the staff must also know their cues; the electricians, for instance, must know when to dim or brighten certain lighting units, by the aid of dimmers. A good dimmer operator will often compensate for errors of the actors in missing their marks by brightening the light if the actors do not come far enough forward or by dimming the light if they come too close. It is such coördination of all departments that makes for success; sometimes a scene that is perfect from the dialog or action standpoint is spoiled because someone did not "hit his marks" correctly. Constant attention and expert handling of the various gadgets by these technicians behind the camera have saved many a production hour for the company.

While modern camera equipment has somewhat simplified these tasks, it is not possible for every unit, even in the major studios, to be equipped with the latest model camera; hence a compromise must often be effected under certain conditions. For example, it is common practice to start a scene with a "big head" close-up or insert, and then dolly back to a medium or long shot. This calls for variable diffusion, and only on the most modern cameras is variable diffusion practicable. A compromise adopted in such cases is the use of a slight amount of diffusion, which softens the extreme close-up somewhat and yet is not objectionable in the long shot. With the new Fox camera and the latest Mitchell camera, the diffusion is adjustable from as soft an effect as may be desired for the big close-up to absolute clearness or no diffusion in the medium or long shot. Since variable diffusion is usually necessary in making dolly shots, an addi-

tional assistant is required to manipulate the device, which leads to crowding on the dolly or rotambulator. Metro-Goldwyn-Mayer Studios have overcome the difficulty by designing a remote-control device for operating both the follow focus and the variable diffusion.

The "set" procedure is as follows: The set is prepared and dressed, and the night crew or "swing gang" rigs the overhead lighting units, deliberately placing on the scaffolds more units than may be necessary, as it is more economical to have the units already in place than to take time to place them once operations on the set have begun.

FIG. 1 An example of overhead lighting.

The cameraman and chief electrician having learned whether the scene is to be a night or day sequence, the electrical crew proceeds to rough in the lighting and wire the necessary fixtures. If the first sequence happens to be an interior shot with the sun shining brightly outside, preparations are made to light the set in a rather high, or day, key. The required, or desired, position of the sun is determined, and high-intensity arc lamps are placed so as to project a stream of light through a door or window, or both, and cast shadows in the proper direction. If both night and day sequences are to be photographed on the same set, then a decided contrast in lighting must

be achieved by keeping the day scenes in a high key and the night scenes in a low key.

The director and cinematographer next confer as to the best way in which to play the action called for by the script, and the cast is called in and is rehearsed by the director. The cinematographer watches the action through a finder which he carries about the set; behind him follows an assistant who marks the floor with small pieces of adhesive tape indicating points at which the actors stop in their motions, while the grip marks the various camera positions so that he

FIG. 2. Dolly shot on location, with booster lights Dolly tracks alongside rails permit trucking shot of incoming train (*Paramount Pictures*)

may lay the track along which the dolly rolls, since a good percentage of shots are made from dollies these days. In the meantime other members of the cast and the crew watch the rehearsal. After the first rehearsal the "second team," or "stand-ins," are brought in, and the cameraman and gaffer proceed to light them in their various positions. The camera dolly is put into place on its tracks and a mechanical rehearsal follows, the stand-ins walking through the action and stopping at the various positions indicated by the tapes on the floor, for the benefit of the electricians, camera crew, and sound men. The

grips, besides timing their dolly moves and seeing that the dolly operates with absolute quiet, search in the meantime for stray light-rays that might strike the lens or the diffusion mediums in front of the lens. After all lights have been "goboed" and dolly movements corrected, the lights are adjusted as may have been found necessary, and the "first team" is called in for a dress rehearsal. This final dress rehearsal with the actors themselves allows the director and cinematographer to make final corrections in lighting and movement. It is not unusual during such dress rehearsals to alter or delete certain lines of dialog; such changes in turn, necessitate changes in the camera movement and dolly timing. After such corrections have been made, microphone shadows eliminated from the camera field, and dolly movements smoothed out, the crew and cast are ready for a "take." Rarely is the first take satisfactory unless the scene is a very simple one. Additional takes, or retakes, are made until a satisfactory one is obtained, with such lighting corrections being made as might be necessary.

Because of the variability of the weather, the unwanted noises of the outdoors, and other difficulties, more and more exterior scenes are being photographed inside the studios. These artificial exteriors are more convincing today than they used to be because of many technical improvements and advances. The speed of emulsions has been increased, enabling the cameraman to "stop down" the lens while using only a little additional lighting. The "special effects" men can assist the illusion by hanging leafy tree branches in such positions as to cast pleasing shadow patterns on walls and buildings; slight motion of the leaves creates a convincing illusion of outdoors. The use of water and glass surfaces, with the proper reflection and agitation, leads to many realistic marine effects in both night and day shots.

Make-up in motion pictures compares to retouching of "still pictures"; in other words the artists must be "retouched" before they are photographed. Naturally there are some whose complexions require hardly any make-up, but in most cases make-up is necessary to cover slight skin blemishes and smooth out the skin texture. Arthur Miller reports that in the production *How Green Was My Valley* none of the cast wore make-up except the mother and daughter. The men were coal miners, and looked the part; however, these same actors in a modern story with a drawing room setting would no doubt have been made up. Most of the studios are well organized with good make-up departments, and their coöperation with the cameramen has been most helpful.

While there is no question that the new high-speed fine-grain panchromatic emulsions and the improved American-made lenses lead to clean-cut photography, the modern electrical equipment is also a very important contributing factor. The lighting units have been brought well under control; the light can be directed by "barn doors" to the spots desired; and numerous other gadgets may be used for screening

FIG. 3. Effect of water reflections, produced by moving broken glass reflecting light from shots

and softening the light in certain areas. Dimmers and their operators play very important parts in almost every scene. Often the camera and operators are so close to an actor that their shadows appear in the scene; by dimming the lamp causing these shadows the objection is eliminated, and the lamp is brought up to its proper brightness after the camera is out of range. Small units are helpful when

working in congested areas, and much credit should be given to the studio electricians for their ingenuity in handling the small units so that they deliver the necessary light without being seen by the camera.

The use of artificial light outdoors is common practice nowadays for the simple reason that it has been found to be an economy. Lamps on location allow quicker set-ups. The units are more flexible and can be placed where desired and, unlike reflectors, need not be placed where the sun is shining. While both reflectors and lamps are used on location, the lamps are much better for close-ups and intimate action; they can be easily controlled and are not so hard on the artists' eyes. For lighting wooded sets and sets in congested areas, lamps are indispensible. It is not unusual to finish a day's work on location after all the sunlight has gone, in some cases after darkness has set in. Matching the artificial light with daylight is an art that most of the men have mastered. Likewise, it is sometimes necessary to shoot night scenes in the daytime; if the locations are picked with discretion and the correct filters and booster lights are used, such night exteriors can be handled economically. When production costs rise for one reason or another, the studios economize, especially on the lower-budget pictures, by using standing sets and cloth backings, and by taking other short-cuts. The cameraman is expected to use his art and imagination in manipulating the lights and the camera so as to cover up such deficiencies.

Practical cinematography has led to many improvements in the art. As newer and better methods become available they are rapidly adopted, necessitating thereby constant changes in the technique used by the cameraman. Recommendations and suggestions of the cameramen have played a part in the development and application of the photoelectric exposure meter which most studios use to establish the key lighting. With increasing use of such precision instruments, pictures are now being printed very uniformly, despite the widely varying types of lighting and effects employed.

The method of calibrating lenses by measuring the transmitted light with a photoelectric meter, as developed by the Camera Department of Twentieth Century-Fox under Dan Clark, has eliminated practially all errors of exposure. A recent test of 150 lenses so calibrated, regardless of focal length, make of lens, *etc.*, and used under identical conditions, gave exact exposure at a given stop. It has also made possible the effective use of coated lenses, giving greater contrast and better definition as compared with uncoated ones.

Putting Clouds into Exterior Scenes

CHARLES G. CLARKE

A landscape that includes a cloud-flecked sky is far more attractive than the same scene without the clouds, particularly in photographic landscapes, where, without the benefit of color, the cloudless sky area is rendered as an uninteresting expanse of monotone. It has long been a major problem of the studios to be assured of obtaining attractive exterior scenes, for a great deal of equipment and personnel are involved when moving a unit out of the studio. It is not possible to decide suddenly to move out to an exterior location; exterior scenes must be planned well and at least twenty-four hours in advance. During the long California summer, weeks on end follow without clouds of any description, and the cameraman is often faced with the problem of having to photograph scenes with little or no pictorial embellishment. Heretofore, in the major productions, it has often been necessary to "dupe" in clouds after the scenes have been made, and sometimes locations at a distance have been chosen where conditions indicated that chances of obtaining real clouds were reasonably favorable. The budget for the average production does not permit the great expense of either of these alternatives; so a process had to be developed by means of which clouds could be produced with dependability and economy.

The process to be described uses appropriate photographic transparencies of real clouds set before the camera, and operates on the principle that the barren sky acts as a printing light. The transparency reduces the light passing to the film in proportion to the density gradations of the transparency. On the finished positive the whitest "cloud" is of the brightness of the unfiltered sky. As photographic emulsions are especially sensitive to blue light, plain sky areas are rendered very bright. This characteristic provides a means of producing bright, fluffy "clouds." Obviously sky-correcting filters are not used, for if the sky is darkened by filters, the brilliancy of the "cloud" is destroyed. An appropriate negative of a sky-scape that has been exposed with good filter correction is chosen. The view should have a perspective and cloud arrangement that will later form a pleasing composition when a transparency made from the negative

is combined with an actual foreground setting. When making the positive transparency, the lower portion is "dodged" off so that the foreground setting may be photographed through this portion which is perfectly clear and transparent.

The transparency is set up before the lens of the camera and is adjusted so that the horizon of the transparency is in proper relation to the horizon of the actual scene. A wide-angle lens is employed and the smallest lens-stop possible is used so that the transparency and the actual scene may be in the same relative focus. In bright sunlight, stops from $f/14$ to $f/22$ are usually desirable. As wide-angle lenses at small stops have great depth of field, the focus may be set considerably forward of the actual objects in the scene, so that the transparency and the most distant parts of the scene may be in equally sharp focus. Coated lenses are of decided benefit to the system because of the better definition, crisper images, and the lack of the "hot spot," often encountered when wide-angle lenses are stopped down greatly.

The process is used principally on location where transportation is an important factor, for which reason the relatively small size of 11 × 14 inches has been chosen for the transparencies. For stationary scenes the transparencies are placed about 18 inches from the lens. For panoramic scenes a device is employed that accommodates films 16 × 40 inches in size. Films are used because they may be curved to the radius of the panning camera and thus be at a uniform distance from the lens. To overcome displacement or "slippage," the camera is so mounted that the nodal point of the lens is at the axis of the vertical tilt and panoram. For the stationary set-up the transparency is attached to the usual matte-box supports, while for the panoramic attachment an auxiliary plate is introduced between the tripod and the panoramic head. To this plate is attached the holder for the curved plates, for obviously they must remain stationary while the camera is panned across the transparency.

This invention has been in use since late in 1939, and many of the productions of this studio have been released with cloud scenes made by this process. Among them may be mentioned *Brigham Young, Hudson's Bay Company, Romance of the Rio Grande, The Cowboy and the Lady*, most of the *Cisco Kid* series, and many others. In many cases these artificial cloud scenes are edited in with real-cloud scenes, and even the cameraman who photographed them both is afterward often at a loss to tell which is which.

Besides offering the great advantage of creating pictorially beautiful scenes under unfavorable circumstances, the method has an important economic value. In a production such as the *Romance of the Rio Grande*, for example, some forty of the scenes were made in this manner. If the clouds had been put in by the matte-shot method the cost would have run into many thousands of dollars. The complete outfit that was used cost less than $100. The set-up is quite simple and is accomplished almost as rapidly as an ordinary set-up. The cameraman has the visual effect before him on his ground-glass. After adjusting the transparency to fit the setting, he is ready to make the scene. Further tests or experimentation are unnecessary. No alteration of the negative is necessary, and it is processed in the usual way.

In addition to simplicity and economy, the method has the advantage over the matte-shot method of being able to place action over the sky area. In the matte-shot and duping methods, it is necessary to keep all action below the horizon, lest such action run over into the division line when the sky portions are later exposed in. The cloud portions of the transparencies are ordinarily perfectly clear, only the areas between clouds having any density. As long as the action stays within the "cloud" it may be placed anywhere in the sky. Buildings, steeples, moving trees, and the like may extend over the horizon. When it is known that close-ups are to follow extreme long-shots in the same sequence, a suitable cloud plate is chosen so that the action may be properly composed in both. Dark objects or silhouettes may extend through the sky portions with no "ghosting" whatever, for they are but obstructions to the printing light of the sky.

As the intensity of the skylight varies greatly, from a direct front-light to an extreme back-light, a great number of transparencies of different densities would be required to suit all such conditions if some means of control were not possible. Such a control is provided by a graduated neutral-density filter. For front-lighted and side-lighted subjects the light is relatively uniform and control is seldom necessary. For back-lighted subjects the sky, hence the printing light, varies considerably from sunrise to noon and on to sundown. For such shots we carry two densities of the same plate. Adjustments between these densities are provided by the graduated neutral-density wedges. If the sky is extremely brilliant and the transparency is rendered too light in relation to the foreground, the neutral-density filter is adjusted so as to retard the sky area only. When the transparency is

rendered too dense in relation to the foreground, the filter is inverted so as to retard the foreground area, allowing the sky area to "print up." Location kits contain about twenty different transparencies including examples of front-lighted, side-lighted, and back-lighted clouds. In some the composition is arranged so that buildings, trees, *etc.*, may extend over the horizon on one or both sides. As the plates may be reversed left to right to suit the composition or lighting conditions, the number of plates required is greatly reduced. From time to time new transparencies are made, and before being put into production their densities are tested photographically. Those that meet approval are put into the location kits. Needless to say this system has the hearty approval of the cameramen. No longer do they dread having to photograph exterior scenes on cloudless days. The directors, likewise, realizing the importance of pictorial beauty in the productions, have been most coöperative in arranging action within the limits of the method.

This system is not intended to replace real clouds. It does, however, offer a fine substitute when nature is not cooperative. Even when there are real clouds in the sky, the scenes may have to be photographed at angles that do not include the clouds. Edited together, scenes with and without clouds are inconsistent. This method fills in the gaps. Dramatic moods may be created by choosing suitable cloud formations regardless of the actual sky conditions at the time. Hazy skies, which are so difficult to control with color-correcting filters, make no difference to the transparency, which requires only a printing light whether it be hazy or otherwise. By using suitably toned or dye-toned transparencies the method may be applied to color-photography.

Rear-projection plates may be made at any time after or before the regular production long-shots have been made. Using the same transparency for both purposes guarantees that the identical cloud effects will prevail in each when the final scenes are edited in sequence. It is impossible to discuss here all the adaptations of this method. The method is constantly used in this studio, and extensions and improvements in the technique are occurring constantly.

Technicolor Cinematography

WINTON HOCH

This essay does not in any way pretend to be a comprehensive coverage of the equipment, methods, and problems of the Technicolor cameraman at the present time, but is intended rather to present some of the items that might be of general interest. Inasmuch as the general technics of motion picture photography are well known and have been frequently discussed in the literature, there will here be presented some of those aspects that are peculiar to, or receive emphasis from, the fact that the camera is photographing in color.

These aspects arise in very large part before photography, and of all the preparation activities that take place before the actual start of photography, two that are very important to the Technicolor cameraman are color design of the sets and costume color selection. The importance of proper color design and costume color selection cannot be overemphasized. The set colors should be chosen with care for hue, chroma, and value, and with a knowledge of the costumes to be used, the relative importance of the set, its cutting and physical relationship to the other sets, and the orientation of these factors with the script. While it is true that the cameraman can control the set effect to a large extent by his lighting, this color control work must be carefully handled or the screen result will not be optimum. Obviously the more adverse conditions the cameraman meets, the more the production is likely to suffer in screen result in production time lost in correcting those adverse conditions, or in both. These two factors of set and costume color probably go farther than any other group of factors in representing the difference between a black-and-white production and a color production. The net result might be termed the "color score" of the picture. It might be compared to a musical score sometimes flashing and brilliant and at other times subdued. It follows that if the problem is ignored, discords usually occur.

Obviously, without sets and costumes in color, the only colors left are flesh tones. A very interesting color emphasis effect was demon-

strated in the RKO picture, *Irene*, where an entire set was designed in neutral tones and the star wore the only color.

To handle this very important set and costume color contact, the Technicolor Motion Picture Corporation has available the services of a color control department to advise on the color design of the sets, the evaluation of costume colors, and allied problems. This department has a background of experience from all productions, and its experience and highly developed judgment are available, through the normal functioning of the department, to each new production as it comes along. This department is the spearhead of the Technicolor photographic activity.

The make-up problem is handled, as in black-and-white pictures, by the studio make-up departments, although the color cameraman does have the responsibility of requesting the "touching up" of the make-up as it may be necessary, and he very often has special problems that require close collaboration with the make-up man. For instance, on exteriors with the actors working in sunshine, they usually begin to sunburn, and make-up changes must be made in many cases to handle these gradually tanning complexions. Frequently this means a new make-up problem in order to keep the camera appearance of the flesh tones the same. It can readily be seen that this can become a difficult job. The reverse is also true. As the troupe begins stage work after returning from the exteriors, their tanned skins will slowly fade and the problem of compensating by make-up continues. Occasionally we have had difficulty due to physical exertion on the part of the principals, causing faces to flush beneath the make-up, which effects the camera appearance.

The color camera is very discerning of flesh quality, and we find it necessary to include in the make-up area the neck and throat, and the hands and arms if they show. On rare occasions no make-up at all is used, and it is frequently omitted when photographing babies, as their clear smooth skin generally needs no correction.

It should be kept in mind that, generally speaking, the primary function of make-up is to correct extremes in colors, cover blemishes, and generally reduce the tone range observed in any average group of persons. If one will note the varying complexions of people, he will readily appreciate that if three or four persons were lined up side by side to be photographed, it would be highly desirable and probably very necessary to correct the flesh tones and greatly reduce the tone spread. This must not be interpreted as meaning that all flesh tones

should appear alike. Variations of tone are very desirable. It is the extremes that are undesirable. Obviously a white man with a heavy tan who photographs like an Indian is not a very convincing white man. The most critical care is given to the close-ups, especially of the principals. The care and attention given to the problem are, of course, directly proportional to the screen importance of the skin tones.

A great deal of time and money has been spent in solving the make-up problem, and literally thousands of feet of film have been exposed and printed on various make-up tests to discover the best make-up materials and technics for the color camera. A proper make-up requires highly skilled artistry in its application.

Other important items to the cameraman are his lights. Here color photography again introduces an important factor of which the cameraman must be cognizant, and which must be watched very closely on certain types of work. That factor is color-temperature. Our present three-strip Technicolor cameras are balanced to an average daylight color-temperature. For true color rendition, especially in the pastel shades and neutrals grays, this temperature should not vary on the set by more than about $\pm 250°$.

There has been in the past some misconception regarding the status of incandescent lamps (designated in the studios as "inkies") with respect to Technicolor photography. Some people have understood that the Technicolor cameras are changed over by filters and prisms to accept an unfiltered incandescent-lamp color-temperature. Others have indicated that they thought that the camera automatically corrected any unfiltered inky light that might be added to an arc-lighted set. These conceptions are wrong.

The filters, prisms, and film of our present three-strip Technicolor camera are all balanced to daylight and this balance is used both for exteriors and interiors. This simplifies the production problem a great deal. First of all, there is manufactured and used only one set of film emulsions. This means that manufacturing, ordering, shipping, storing, exposing, and developing are all standardized for one system, with all the obvious attendant advantages, not the least of which is a lower negative cost.

This single standard also simplifies set-lighting problems, both interior and exterior. All regular Technicolor lighting units have been balanced to this daylight color-temperature by actual and repeated tests with the Technicolor camera. Therefore, they may all be used

interchangeably as far as color-temperature is concerned. The only other factors governing their use are the very direct functional ones such as size of unit, light output of unit, operational characteristics of the unit, the type of light that it gives (that is, whether a "hard" light or "soft" light), and the unit efficiencies with respect to light output *vs.* current input, and with respect to light output *vs.* the throw required of the unit for the particular job in hand.

The more common units used for general production are (HI = high intensity):

The 150-ampere HI arc
The 120-ampere HI arc
The white-flame Twin Broad arc
Inky Sr. spotlight
Inky Jr. spotlight
Inky Baby spotlight

Among others less frequently used but frequently no less important should be mentioned many special converted lamps, a 65-ampere HI arc spot, and a 10-kw corrected inky lamp.

The light-sources used for photography might be classed in four general groups as follows:

Daylight
High-intensity arc light
White-flame arc light
Incandescent light

The daylight, of course, is our standard for color-temperature. The HI arc lights are all corrected for normal work with a *Y-1* gelatin filter placed in front of the arc light. This filter was especially made for Technicolor, using a special non-fading yellow dye supplied by us. The exact filter strength is determined by camera test. The white-flame arcs were balanced to a daylight color-temperature by the National Carbon Company, and therefore require no filter of any kind. The incandescent lighting units must fulfill two requirements to meet the daylight color-temperature standard. They must first be equipped with incandescent bulbs burning at a color-temperature of 3380°K, and second, they must be fitted with a tested Macbeth glass filter. All General Electric bulbs marked *C.P.* will burn with a color-temperature of 3380°K when operated at their rated voltage. It should be emphasized that the rated voltage must be supplied, and in the case of the arcs, the proper amperages and proper gap lengths and positions must also be maintained.

Daylight as a source probably presents fewer troubles, although very early in the morning and very late in the afternoon trouble is frequently encountered. An interesting difficulty occurred early one afternoon when the smoke from a forest fire filtered the sunshine to such a brownish orange hue that it was necessary to abandon the location for that day.

The conditions just outlined do not have to be met at all times, but they should be adhered to if a pure white light is necessary and desirable for the work in hand. Certainly there is no limit to the effects obtainable with colored lights. For instance, frequently straight unfiltered flickering inky lights are used to produce a warm glow on the costumes and faces to simulate firelight. Artistic sense and experience must dictate the extent to which colored lights are used. The colored-light possibilities have been frequently used, perhaps most recently and extensively in the colored shadow and live action sequences in *Fantasia*. Its first featured use in three-color pictures was in the first three-color production, *La Cucaracha*.

The rigging and lighting of a color set is similar in many respects to that of a black-and-white set, with the exception that lighting units balanced for Technicolor are the units used, unless effects are in order. Most Technicolor sets rely upon arc-light units for the bulk of the lighting. The large sets especially use the larger arc units. Some of the very small sets are from time to time lighted entirely by corrected inky light. Inky units are valuable also on big sets as auxiliary lighting units. They must be watched for age and cleanliness, as an aged bulb and a dirty reflector, filter, and lens can substantially reduce the lamp output. Needless to say, cleanliness is also an asset with arc-light lenses, and proper maintenance and servicing of all lighting units are important.

Exterior sets and set-ups are also handled in a very similar manner to black-and-white set-ups. Scrims, nets, reflectors, and booster light all play their part. It should be noted that the so-called gold reflector is not acceptable in color work (unless for effect) for obvious reasons.

The color-temperature factor is once more introduced when reflectors are extensively worked. The term *daylight* has been advisedly used. By definition, daylight is the light from the entire sky, including direct sunlight if the sky is clear. Sunshine has a color-temperature of about 5500°K, while blue sky has a color-temperature varying from 10,000° to 20,000°K. When reflectors are used as lighting aids

they select only the sun, which is reflected into the scene, and introduce a filler light that is warmer in tone than daylight. In addition, it must be remembered that the so-called silvered surface, which is usually aluminum or tin, reflects slightly less blue than it does red and green. This factor also adds slightly to the effect of a lower color-temperature. For these reasons reflectors are not considered as desirable as booster light for some purposes. This is especially true of close-ups where flesh quality is of critical importance.

FIG. 4 Scene from *Captains of the Clouds* showing use of booster lights for Technicolor exterior shot (*Warner Bros.-First National.*)

Process photography in Technicolor is now largely a matter of routine. The scenes selected for process work are, of course, subject to the usual limitations for that type of work, but astonishing results have been obtained. Progress in this field can be largely attributed to two factors: improvement in plate quality, and improvements in background projector equipment. As Technicolor production film is processed day by day, the technical crews improve in skill and the research groups add their contributions, to the end that the process plates now furnished to the studios are specially printed for the optimum contrast, color-quality, and density required for this type of

work. The equipment combinations of each studio have been photographically tested for color-balance, and this color-balance is also taken into account when the plates are printed.

It has been found that background projectors vary appreciably in the color-quality of the projected light. Generally speaking, the projectors using reflectors have a little more blue in the light than the condenser projectors, although this color-quality varies appreciably, depending upon the condition of the reflector and the nature of its surface, or upon the glass used in the particular condenser set-up in use. Some condenser lenses have a very pronounced yellowish cast that is not very desirable for color work.

There has been appreciable pressure in the last few years aimed at increasing the background projector outputs. The present high outputs have resulted from improvements in carbons, objective lenses, projector optics behind the objective lens, and lamp house, and in the successful combination of several projectors for throwing superimposed, matched, and synchronized images onto the process screen. Astonishing progress has been made toward increased output, and fortunately these developments reached the point where they were incorporated into production equipment before the present war appreciably curtailed progress in this line.

The Academy of Motion Picture Arts and Sciences and many studios and equipment companies have all contributed to this projector improvement problem. As a result, we very frequently photograph screens in color more than 20 feet wide, and have photographed, in color, process screens approximately 28 feet wide. This size was used in the Paramount-de Mille production *Reap the Wild Wind*. A shot has recently been made by the same studio using a split screen including a total camera spread of 50 feet. This was accomplished with the aid of two triple relay projectors incorporating the recent improvements previously mentioned. In this emphasis on large screens it should not be forgotten that miniature screens also have their uses, and can be successfully handled on the same general basis as the large screens.

The problems faced by the color cameraman in handling process photography are generally about the same as those found in all process work. However, he must be very color-conscious and on his guard against an off-color projector light and improperly burning foreground lights. He must also be very careful of his foreground-to-background balance, as a background that is carried too high will

often present a burned-out appearance that greatly alters the color values of the plate, and destroy the illusion of realism that he is striving to create.

Modern Technicolor camera equipment closely parallels the black-and-white studio equipment in its principal operational features and functions. There are available, for the camera, lenses of 25, 35, 40, 50, 70, 100, and 140-mm focal-lengths. They are all in carefully calibrated mounts that fit onto a master focusing mount on the camera. In almost all cases focusing is accomplished by actual measurement to the focal plane desired, and then the lens is set on this indicated calibration. Repeated tests have shown that this method is more accurate than eye focusing. Eye focusing is seldom resorted to unless the focal distance is so short that it exceeds the lens calibrations. The stop calibrations on the lenses are all photometrically determined and calibrated on an arbitrary arithmetic scale. These lenses have all been specially corrected for Technicolor work. A very interesting and very valuable follow-focus aid, which has been standard equipment since the manufacture of the cameras, is available to the assistant or technician in the form of a pair of selsyn motors. One is attached to the lens mount, and the controlling motor is held in the technician's hand, or fastened to some support if desirable, permitting the technician to be 50 feet or more away from the camera, and yet maintain accurate control over the lens focus. This is of especial value when the camera is put into the sound "blimp," making actual rigid mechanical connection with the lens-mount unnecessary. This is very helpful on sound shooting inasmuch as the camera unit inside the blimp is actually floating in rubber and has no direct mechanical contact with the blimp except through this sponge rubber.

The non-rigid relationship between camera and blimp suggests another problem that has been solved in a very successful manner. That is the problem of attaching a finder for the use of the camera operator. Obviously, if it were attached to the outside of the blimp, the camera, inasmuch as it is floating, could be framed differently from the way indicated by the finder. This was solved by designing a very compact finder, and attaching the main optical elements to the camera. Auxiliary optical elements are available for use depending upon whether the camera is used with or without the blimp. This compact design has the additional advantage that this same finder is used with the camera for almost 100 per cent of the work; thus only

one finder and one set of mattes are necessary for each camera, and the camera operator has only one set of finder conditions for which to make allowances. Auxiliary finder allowances are *always* necessary to compensate for the parallax errors both in front of and behind the focal plane for which the camera is adjusted.

The camera motor arrangement is highly flexible and worthy of special note. There are eight types of motors and eight combinations of motor-to-camera gears, all of which can be changed in the field. The only requirement of the cameraman is to specify the kind of shooting expected and the electrical current or the kind of distributor system to be used. The regular cameras can also be successfully operated running backward at full speed. Speeds higher than 24 pictures per second, either forward or backward, are not permitted with the standard cameras.

The camera unit has available all the standard camera mounts to which the industry is accustomed. The wild camera can be mounted on anything from a camera spider to a high tripod, and on any other piece of equipment as may be desired, such as dollies, three-wheel perambulators, four-wheel velocilators, booms, rotating mounts, *etc.* The camera, incidentally, has been successfully operated in all possible positions.

For sound shooting the standard camera is used in connection with either a "barney" or a blimp. The barney is necessarily not so efficient from a sound standpoint as the blimp, but it is very useful in a great many places. The regular blimp is a highly efficient piece of equipment, and of course requires heavier mounts than the wild camera, but it can be accommodated on all types of mounts. Those most popularly used are the blimp "high-hat," four-wheeled "velocilator," and a variety of booms.

The many items of special equipment available to the Technicolor photographer are far too numerous to be described in detail. Among them should be mentioned, however, the variety of equipment and mounts used for air photography; the camera blimp and mounts used for underwater photography; and the speed-cameras capable of consistent operation at so-called six times normal speed, or 96 pictures per second.

The question has been asked if an extra standby camera was kept on the set at all times to replace the camera in use when the film ran out, because it took so long to thread the Technicolor cameras. This is not true. The actual threading time of a Technicolor camera is

only about three minutes, for a skilled technician, and many units work with only one camera. On major production units, however, an extra camera is usually kept on hand, threaded, to prevent any possible loss of production time due to many reasons. Sometimes a reduction of the three-minute threading time is desirable, and when sound shooting is involved and a certain emotional tempo or mood has been established with the principals, unnecessary mechanical interruptions are highly undesirable. Frequently the director requires two cameras on a shot, and the fact that the supply of extra cameras is often many miles from the stage has an important bearing upon the desirability of this extra camera. The additional cost of the extra camera is a very minor item and the camera usually saves much more than its cost by the saving of production time.

This equipment has been in service for many years, and has successfully met the test of almost all climates, altitudes, and conditions. The cameras have been in all parts of the world—into the crater of Mt. Vesuvius, under the sea near Nassau, almost 20,000 feet above the Andes in South America, in tropical climates, and in subzero temperatures.

Cartoons and all types of animation photography also should be mentioned. The bulk of the cartoon and animation work is now handled by adapted black-and-white cameras using the successive-exposure method. These cameras are set up with a balanced set of three-color filters in the optical system at some point, the filters either rotating or sliding, and the color-exposures are made by exposing one frame of film through each filter successively. At the head end of each roll of film a special chart is photographed, permitting the laboratory to identify the various frames. This negative, after development, is printed on a step printer that prints each third frame only. Thus the records are separated and the prints handled in a manner similar to other standard prints. This method is limited to work where no movement takes place during the exposure, and great care must be exercised in the lighting, exposure, registration, development, and color-balance of the film. The cameras must be serviced to rigid mechanical specifications, and the lenses should be color-corrected. A great deal of careful work must be done to set up such a system, and reasonable care observed in the shooting. Once the system is set up, however, these items are handled largely on a routine basis and with reasonable facility. This type of photography can not be intercut with the standard three-strip negative unless dupe negatives are made.

Other very valuable technics and facilities that are available and are very successfully executed in current production today are glass shots; double and multiple exposures; double and multiple printing; wipes, fades, and lap dissolves made in the laboratory; and many combinations of these. The possibilities are numerous.

While speaking of effects photography, fluorescent materials, paints, inks, *etc.*, should be mentioned. This is a field that has not received much attention due to lighting equipment limitations; however, it can be accomplished in Technicolor. A very simple test was recently made to indicate some of its possibilities. Fabrics colored with fluorescent materials were photographed using as an ultraviolet source a Type *170* M. R. HI arc, covered by a 12-inch ultraviolet Corning filter. The arc unit was positioned 12 feet away from the illuminated subject and the spread obtainable with the filter was about $6^{1}/_{2}$ feet at this distance. The brightness of the fluorescent fabrics was sufficient to give an acceptable Technicolor negative with the camera operating at the normal speed of 24 pictures per second.

Routine studio Technicolor photography has long since passed the experimental stage. It is now handled with the same efficiency and dispatch as many black-and-white units. The negative is developed at night and the negative reports, negative clippings, and estimated printer points are delivered to the Technicolor cameraman on the set the following morning. Black-and-white rush prints, if ordered, are generally delivered the following afternoon, and the color rush prints are delivered the following evening.

The negative reports and all laboratory contacts are handled for the cameraman through the Technicolor camera department, which also checks the daily log sheets, and by these log sheets keeps a very complete record of every production and of every scene photographed on that production. The records have proved invaluable, not only to the cameraman, but on many occasions to the director and others participating in the production. This most excellent coördinating agency is extremely valuable.

Further production flexibility would be available if a single film capable of being exposed in any ordinary black-and-white camera could be used for a full color record. Technicolor's Research Laboratory has spent many years in the development of a monopack type of film that would fulfill this requirement. Progress on the project was reported by Dr. Herbert T. Kalmus, President of Technicolor Motion

Picture Corporation, to its stockholders in his Annual Report for 1940, as follows:

"Your company's research engineers have also been engaged in cooperation with Eastman Kodak Company on a process of photography employing a single negative or monopack instead of the three strips, and on which three emulsions are superimposed on a single support. Your company's officers and technicians are frequently asked when Technicolor monopack prints will be available. Their current interest in the monopack process is not primarily for release prints because the triple-layer raw film appears inherently to be so expensive that it could hardly compete in cost with Technicolor imbibition prints in the long run.

"But your company's officers and engineers do believe that monopack will be developed to be satisfactory for use as originals from which Technicolor imbibition prints can be made. Such an original could be exposed through any standard black-and-white motion picture camera and should thus have mechanical and cost advantages over three-strip negative.

"Work on this monopack process for originals has been in progress for several years, and has lately reached a point of decided encouragement for certain purposes. At present the monopack research program includes a number of experiments of semi-commercial character which are promising for photography where camera size, mobility, operating speed, or other special considerations are of extreme importance. The expectation is that it will first be tried in a limited way for the special purposes indicated, to be matched and cut in with the larger part of a picture photographed by the three-strip method. It should be borne in mind that Technicolor three-strip photography is constantly improving in quality so that imbibition prints from monopack have not yet overtaken the present quality of imbibition prints from three-strip."

The expectation outlined in Dr. Kalmus' report has been largely realized, and since that time monopack has been used in several pictures, including *Dive Bomber* and *Captains of the Clouds*, where shots from airplane wing-tips and other difficult locations were required; in the industrial field; in military training films; and in special-effects photography where mobility and high speed are important. These uses of monopack are considered as commercial experiments serving the dual purpose of fulfilling a special need of increased flexibility in the field of color photography and of pointing up production require-

ments which are not easily determined even on the large-scale test basis that characterizes Technicolor's research program.

Technicolor does not consider that the quality of prints from the monopack method of photography has reached the level of quality of prints from its three-strip process. This is due not to any lack of progress in monopack research but to the rapid improvement of three-strip Technicolor which, like all phases of Technicolor's process, receives emphasis from its research group.

The present monopack process, in latitude, visibility, and tone rendition is satisfactory, but the picture texture, in grain and uniformity, has not attained the smooth, fine texture of three-strip. The problems involved in correcting these deficiencies are receiving attention and progress is being made.

Technicolor is now and has been for some time definitely on a routine production basis, with almost all the technics used in black-and-white available in color also. The experimental phases have definitely long since left the production field, and have taken their place in the Technicolor research department, which is currently very active and from which the results flow quietly but efficiently to the production field without disturbing changes.

SPECIAL PHOTOGRAPHIC EFFECTS

FRED M. SERSEN

Summary.—*The department for special photographic effects is the natural outcome of the difficult problems which develop in motion picture production. Certain scrips are so written that the ingenuity of this department is taxed to the utmost to produce the effects required for visualizing the scenes described. Moreover, the more critical attitude of the public in analyzing the results of trick photography necessitates absolute perfection of the final visual record.*

Economy in the matter of time and finance has spurred the special effects branch of the industry to its present high level. Many scenes would be impossible to produce because of prohibitive costs in set construction or the impossibility of photographing them in natural settings.

To have a highly efficient working organization, the department must have as a nucleus a competently trained camera crew that specializes in this particular work. At their disposal should be a thoroughly equipped camera room with cameras, projection printers, animation machines, laboratories and trained laboratory men, and a cutting room and experienced cutter.

Working in conjunction with the cameramen are the matte artists. These men must not only be fine artists, but must have a knowledge of architecture, and the ability to match in paint the most delicate tone values in the film.

The shooting of miniatures, and the scenes and actors that will go into composite shots, should be supervised by this department, to give it full control over all the component parts of such shots.

Matte Shots.—Matte shots are the most often used form of special photographic effects. A scene is photographed on the set and only enough background is needed to back up the action. This applies particularly to ceilings on large interior sets, tops of buildings for street scenes, distant landscapes, and foregrounds. The procedure

is either to matte the shot on the set, or to photograph the scene without a matte and then make a dupe, at which time the matte is used. This is done by using a painted white surface of such form as to allow only that portion of the film to be printed that is to form part of the scene. The remainder of the surface is painted black to prevent exposure in the part of the scene that is to be filled in by painting. The shot is then taken over by a matte shot artist, who, in accordance with the design furnished by the art director, paints the picture necessary to complete the matted-out portion of the shot.

When the painting is far enough advanced it is exposed into the dupe that was previously made, to determine the exposure. This is done by exposing a length of four or five feet of film, which is developed immediately and analyzed for exposure, as well as for the tone value of the painting, which is corrected either by changing the exposure or by changing certain tones in the painting, or both. This procedure is repeated until the proper balance between the painting and the dupe is attained.

In shooting a matte shot the camera should be set upon a solid foundation and braced to prevent any possibility of vibration.

Glass Shot.—Glass shots were among the first special photographic effects but have been largely replaced by matte shots. A glass shot is used today only when it is necessary to finish the shot at the time it is photographed, or when panning of camera is required. When shooting a panning glass shot the camera must be set upon a special head, so that the center of the lens is at the pivot of the pan.

The artist paints the necessary background, which must be matched perfectly in tone values for a definite kind of lighting. This makes it necessary to photograph glass shots at a certain time of the day to match the lights and shadows in the painting, otherwise hurried changes are necessary in the painting that are invariably detrimental to the quality of the shot.

Painted Insert.—Painted inserts usually embrace theater marquees, street and building signs, static establishing shots of countrysides, *etc.* These are painted by matte artists on 3 × 4-ft boards from designs usually furnished by the art directors, and such scenes are fully developed either by the artists or by redesigning enlarged photographs of stock shots from the film library, or from stills.

Composite Shots.—A composite shot is a combination of two or more separately photographed scenes into one picture. In some instances ten or twelve exposures are put together in a finished scene.

This type of shot is used principally to create scenes of large crowds of people such as theater audiences, mob scenes in streets, *etc.*, and is of great value in saving time on the set and in making possible the use of the same people in various positions, thus eliminating the necessity of hiring a great crowd of extra talent. For example, the interior of a theater auditorium is divided into sections, the size of each section being gauged by the number of available talent allowed by the budget. The people are moved from section to section until all the sections are photographed from the same set-up. If the scene calls for simultaneous stage action, the action can be photographed at a later date and combined with the final composite. This is one of the simpler forms of composite shots.

An example of a more complicated type of composite occurs in *The Rains Came.* Action called for an earthquake, with portions of the ground opening up and portions sinking; people running away from the crevasse and being trapped by falling debris from buildings tumbling down in the background. The procedure for making this kind of shot is briefly as follows: A sketch is carefully made to portray the action of the people and the elements involved, keeping constantly in mind the mechanical requirements. After the sketch is completed it is broken down into the various sections that will comprise the finished scene: first, the set in which the people will be photographed, keeping in mind the number of people available in order to determine the number of sections that will have to be filmed; second, the miniature of the sinking ground and the miniature of the buildings tumbling down. These must be figured to the proper scale, each as a perfect unit, so that in the finished scene all the parts will fit together like a jig-saw puzzle. To accomplish this a complete set of drawings is made, covering the set, camera set-ups, proper time to shoot each section, *etc.* Such working out of the details is necessary to eliminate guesswork and to assure a smoothly running unit when the scene is photographed.

It is very important that the action of the elements and of the people be accurately coördinated, in order to determine the correct footage needed for the scene; this is particularly important when animated travelling mattes are to be used.

Miniatures are then shot to establish coördination with the action of the people, or *vice versa*, and the scene is ready to be put together. The scene of earthquake and falling debris was made by using stationary mattes for printing certain sections of the scene, and, where

necessary, travelling mattes, for combining these sections with the other sections. The scene was then brought to completion by painting in the sections not covered by sets or miniatures.

Another kind of composite permits the use of a small set, or a portion of a set, by photographing the set from various camera set-ups so that the combination of the shots results in a picture of a larger set. For instance, a shot calling for a four-story building, showing action at the windows, can be made by building a set of only one story and photographing it from four different levels.

Split Screen.—Up to a comparatively short time ago, split-screen shots were made on the set, but there was always the possibility of a slip-up in synchronizing the action. The improved method is to photograph the various parts of a scene on separate negatives from the same set-up with the same lighting. This makes it possible to synchronize and match the component parts more accurately.

Double Exposure.—Ghost effects are typical examples of double exposure. They are accomplished by photographing the two components separately, resulting in better photographic balance and synchronism of action.

Animation.—Animation covers a wide field, such as putting lights into night shots of moving objects—boats, trains, headlights of automobiles, gag shots, bullets shattering windshields of automobiles, animated map diagrams, flashing letters and signs, and practically everything that can not be done on the set in regular production.

Travelling Matte.—Travelling mattes are primarily useful in combining people or moving objects with another background—either rear or miniature, or painted—such as buildings falling upon people in earthquakes, forest fires into which are put actors, battle scenes, floods in which people are engulfed, and many other composite shots where the stationary matte can not be used.

The object to be photographed is usually shot against a backing of high tone with the object itself, *viz.*, a man dressed in white clothes would be shot against a dark background or *vice versa*.

There are several systems for making travelling mattes, all of them intricate, and highly trained technicians are required to complete such shots successfully.

Storm Effects.—It is often impracticable to use storm effects such as rain, snow, fog, dust, lightning, *etc.*, at the time of shooting scenes on the set. When such is the case the scenes are photographed

without the effects, and they are later put in by more suitable methods.

Duped Shots.—In exterior shots, owing to the vagaries of weather and shooting schedules, it is often impossible to achieve correct photographic balance throughout a sequence. This is particularly true where dust, fog, and rain are concerned. By duping such shots the photographic quality of a scene can be controlled, thereby obtaining a more uniform balance for the entire sequence.

Miniatures.—Miniature scenes are very often necessary to create an illusion of reality. To photograph some scenes full size is impracticable, often impossible, due to risk of life and prohibitive cost. For example, scenes of automobiles falling over cliffs or struck by trains, fires, floods, and explosions are only a few instances in which the risk would be too great.

The miniature is one of the most important special photographic effects. The factors contributing to success in photographing miniatures are scale, perspective, detail, color, lighting, and cranking speed of the camera. The men assigned to this work are specialists, and require years of training.

The scale of the set is the starting point, and is determined usually by the kind of miniature needed. Whenever possible the set is built as large as is practicable and economical. Perspective is important to create the proper effect. Due to the fact that miniatures are photographed at relatively short distances, it is difficult to keep the focus sharp from the foreground to distant background. This sometimes calls for "forced perspective" in the construction of the set. An example of this is the scene from *The Rains Came*, in which the flood waters rush over people running across a bridge. The real bridge, with the action of the people, spans Arroyo Seco in Pasadena. It is a long bridge, and it would have been impossible to carry it in focus throughout its entire length. In the reproduction, therefore, it was foreshortened to about one-third its actual length.

The amount of detail in miniatures is related to the scale, the distance of the set from the camera, and the time of shooting the scenes, *i. e.*, day or night. Miniatures must be lighted and painted so that the illusion of full size is accomplished. An instance is a "break-away" miniature of a brick building; all the loose parts are to be completely painted and then assembled.

The last, and probably the most important factor, is the cranking speed of the camera. This again depends in a great measure upon

the scale. The effect of the mass and weight of falling objects in miniatures is achieved by turning the camera at greater than normal speed.

Coördination of all these factors is essential in achieving the final result. Action cranked at high speed, finally appearing on the screen at normal speed, often happens in a split second. This calls for ingeniously rigged controls which are usually manually operated.

With the advancement in the duping of technicolor film all the foregoing effects can be, and are, done in technicolor as effectively as in black and white. Two years ago combination shots had to be photographed with background projection, which process lacks the scope to produce satisfactorily all the special photographic effects demanded in modern picture production.

RE-RECORDING SOUND MOTION PICTURES

L. T. GOLDSMITH

Summary.—*The nature of re-recording as it applies to motion picture production is described in some detail by showing what happens to a typical picture in the re-recording department after shooting on the set has been completed and the picture has been edited to the satisfaction of the producer.*

Sound is added to those portions of the picture that have been photographed silent because of the difficulty or impossibility of recording the corresponding sound at that time, as for example, credit titles, montages, miniatures, stock shots, and scenes photographed silent to playbacks of pre-recorded sound. Music that has been especially scored and recorded for the picture together with appropriate sound-effects is added to heighten its dramatic presentation.

Improvements in dialog quality are made if required by employing electrical equalizers, although distortion is often purposely introduced where telephone, dictaphone, radio, and similar types of quality must be simulated as required by the picture.

Proper balance of the relative volume of the dialog and accompanying music and sound-effects is determined to the satisfaction of the re-recording supervisor. All the sounds from as many as a dozen or more different sources are re-recorded to a single composite sound-track which is afterward printed with the picture to make up the final print to be projected in the theater.

The organization of the re-recording department is discussed and the duties of various members of the personnel are outlined. Crews are so made up that an average of from three to six pictures are in work at the same time.

A division of the sound department of every major film-producing studio is known as the re-recording department, sometimes called the dupe or dubbing department. In the days before sound pictures it was common practice in the laboratory to make duplicate picture prints or "dupes," as they were called. Also, the special picture-effects department would often add foregrounds or backgrounds to a picture, a process termed "dubbing in" or "dubbing." So, in general, the duplicating process, with the finishing touches added, became known as duping or dubbing.

The sound-duplicating process, especially since it is not photographic but electrical duplicating, is more properly known as re-

recording. As the name implies, sound originally recorded on film in synchronism with the picture being shot on the set is recorded again from that film along with added sound-effects and music recordings onto a second film. This film is a composite of all the desired sounds required for the picture. The composite sound-track is then printed on the same film as the corresponding picture and projected in the theaters.

Suppose we take a typical picture as an example, and follow its progress through the re-recording department. After the shooting of the picture on the set has been finished, the picture editor assembles the daily prints of picture and sound-track in proper timing and continuity. These two prints are known as the cutting picture and cutting track. The producer who is responsible for this particular production runs the picture in this form with the editor, and indicates what changes he wishes made. When the picture is complete and the corresponding original dialog sound-track is approved, the editor delivers the picture to the re-recording supervisor.

The film is received as separate picture and sound-track reels, which are close to 1000 feet long. The sound-track consists almost entirely of dialog and any sound-effects that may have happened to be recorded at the same time. The supervisor assigns the picture to one of the re-recording crews who check it reel by reel.

The re-recording crew usually is made up of a re-recording mixer who acts as the crew chief, two sound-track editors who edit the music and further edit the dialog track, a sound-effects editor who prepares appropriate sound-effects for the picture, and a projectionist. The sound-track editors usually split up the reels between them, each man taking every other reel. They check the reels for synchronism and for words of the dialog that may have been cut off because of picture cuts. These will require an overlapping of two sound-tracks in re-recording.

As the reels are run one by one, the sound-effects editor makes notes as to what kinds of sound-effects are required and where they should go into the picture. Some sound-effects are recorded especially for the scene at the time the picture is shot. When such effects are made, the production mixer sends a memorandum to the re-recording department, identifying by scene and take number the effects that have been recorded and noting where in the picture they are to be used.

The sound-track editors then run the sound-track and picture in

a moviola and make notes in ink on the sound-track film, indicating for the laboratory negative cutters which scenes are to be extended, and what scenes and effects are to be removed. Additional prints of the required scenes are ordered from the laboratory, which are assembled into a secondary dialog track to allow some of the dialog sentences to overlap when it is re-recorded. At the same time, the sound-effects editor orders the required number of sound-effects prints from the laboratory, both those made at the time the picture was shot and those made from sound-effects negatives kept in the sound-effects library.

The picture and sound-track are then sent to the laboratory, where two composite sound-and-picture dupe prints are made. One of these dupe prints is sent to the music department, where it is used for checking the picture to determine where music must be scored. The other dupe print is sent to the re-recording department. The laboratory then cuts the original sound-track negative in accordance with the edge-numbers and inked instructions on the cutting sound-track, and makes a print. This may be called a primary dialog print, and is the print used in the re-recording. It is necessary to re-record from this new primary dialog track rather than from the original cutting track because in the new track certain dialog sequences have been extended or removed at the laboratory to take care of overlaps. Furthermore, the original track has become scratched from the many runnings in the picture editor's moviola, and the new track has been blooped at all splices. When the laboratory delivers to the re-recording department the new primary dialog track, the additional prints of portions of the dialog, the prints of sound-effects, the composite dupe print, and the original picture and sound-track prints, the editors begin to prepare the reels for re-recording.

The sound-track editors, using the original cutting picture and cutting track as guides, prepare the secondary dialog track which will cover the overlaps in conjunction with the primary dialog track. At the same time, the sound-effects editor, using the dupe-picture print as a guide, cuts his sound-effects prints into reels to match the picture action. He may have the sound-effects on several reels because often more than one effect is required at one time. In addition, there are usually several loops of sound-effects which run all the time during the re-recording of the reel and can be mixed in as required. The loops are numbered and catalogued and consist

of the more frequently used sound-effects such as laughter, applause, crowd noise, street noise, *etc.*

If the music recordings or "takes" are now available, the sound-track editor prepares the music tracks for re-recording, using the cutting-picture as a guide and following the footage notes prepared for him by the music department as to what the music selections are and where they go into the reel. Several music tracks are often required, and here again additional prints may have to be ordered to take care of overlaps in the music. As soon as a reel has been prepared either with or without all the music and effects tracks, it is run once to check for synchronism, overlaps, effects, *etc.* If no music has been received for that particular reel, the sound-track editors then set it aside and prepare another reel.

The sound-track editors prepare a cue sheet for the re-recording mixer to use during the re-recording of each reel to indicate to him where the secondary dialog and music tracks come in and go out. A similar cue sheet is prepared by the sound-effects editor for his own use when he assists the mixer in re-recording the reel. These cue sheets must be corrected as changes are made during re-recording rehearsals, so that after the re-recording is made and the sheets are filed, they will be accurate if at some later time they are used again.

When all the tracks are prepared, the re-recording mixer and the sound-effects editor, acting as an assistant mixer, proceed to rehearse the reel for re-recording. The mixer usually handles the dialog and music, and the assistant mixer handles the effects tracks. All the tracks, usually eight to twelve in number, are threaded on re-recording machines by machine-room attendants, and the speech circuits patched to the desired mixer controls on the mixer console. The projectionist who has the cutting or dupe picture to project on the screen as a guide to the mixer threads his print on a silent projector. In addition to the picture screen for watching the action, the mixers have an illuminated footage indicator similar to a veedor counter, which is used with the picture for cueing the various sound-tracks. A peak-reading neon volume indicator and theater-type loud speaker behind the screen serve as guides to the mixers as to the volume and balance of the dialog, music, and sound-effects tracks.

After a number of rehearsals, depending upon the complexity of the reel, the re-recording supervisor is asked to approve a rehearsal. If he approves, a recording or "take" is made of the combined tracks on a film-recording machine. The film is sent to the laboratory as

the re-recording crew proceeds to the next reel. (It might be mentioned here that a picture is not always re-recorded reel by reel consecutively, because some reels may take longer to prepare for duping than others.)

The following morning a checking print made from the sound negative is delivered by the laboratory to the sound department. This is run by the sound director in a review room with the cutting picture. It is carefully checked for synchronism, volume, quality, balance of sounds, and quietness. If the re-recording is judged faulty in some respect, the entire reel or part of it is ordered re-recorded again. Usually the reel is satisfactory and the laboratory is notified that a composite picture and sound print of it can now be made. The laboratory first cuts the original picture negative in accordance with the cutting picture print edge-numbers, and then makes the composite print from this and the re-recorded sound negative. When all the reels have been re-recorded and a composite print made of each, the picture is previewed in a neighboring theater.

If there are changes to be made after the preview, the picture editor makes the required changes in the cutting picture and sound-track, and again delivers the affected reels to the re-recording department. Sometimes the changes are such that the previously re-recorded sound-track negative need only be cut to match the picture cut, but more often a re-recording has to be made of the sections affected, usually one or more small sections of reels, sometimes entire reels. A checking print of the new sections or reels is approved by the sound director, and the picture is either previewed a second time or is approved for making composite release prints.

In the meantime, the re-recording crew has usually received another picture and begun its preparation for re-recording in the same way. The re-recording department has several such crews so that a number of pictures can be in various stages of re-recording at any one time.

In addition to the re-recording crews that work directly on the picture there are the machine-room personnel who thread up the re-recording machines, and a man who is responsible for the recording and operation of the recording machines. Often several machine-room men and a single recordist are sufficient to handle the equipment for three or four re-recording crews. A transmission engineer, or maintenance man who sometimes is also the recordist, maintains all the electrical equipment. The mechanical equipment is usually

maintained by men who care for the rest of the equipment in the sound department as well. A representative of the music department is often assigned permanently to the re-recording department who is responsible for the music cutting, and acts as contact between the two departments. A film clerk receives all incoming and outgoing film and acts as general secretary to the department.

In connection with the re-recording of a picture, the re-recording department is called upon for a variety of duties other than those mentioned. Pre-recordings may be required for timing the photographed action on the set to a previously recorded song or dance number. Frequently the music recording for this has been made in sections. Perhaps a separate choir track of voices, an orchestra track, or even added tracks of trumpets, drum beats, or other effects may be needed. To permit the chorus and dancers to perform in proper tempo while they are being photographed without sound, a composite sound-track is played back to them on the set through loud speakers for timing. This track is made in the re-recording department by editing the various music tracks or parts of tracks, and re-recording them to the playback film or disk.

Timing or "tick" disks are similarly prepared for the use of the orchestra in music scoring. The ticks are made in a special machine and so spaced that, when played back to the members of the orchestra through headphones, the musicians will be in tempo with each other and with the action of the picture.

The re-recording department is equipped to record acetate disks at either $33^1/_3$ or 78 rpm, as in some cases songs and musical numbers are re-recorded from film to disk for talent rehearsals at home or for music-publisher auditions. Microphone pick-up facilities are available for recording sound-effects and wild lines of dialog. These can be timed by watching the picture on a screen or by following the dialog played back through headphones.

Many kinds of circuit equalizers are used to distort the quality of speech or music purposely to simulate radio, telephone, dictophone, or other types of sounds. An "echo chamber" is available to simulate voice sounds in large halls, caves, *etc.*, and to add reverberation and life to some kinds of music. Sound-tracks are often run at variable speeds to achieve special effects, particularly in cartoons.

No description has been given of the actual equipment, both electrical and mechanical, that is used in re-recording. There are many kinds of machines used for special purposes, and an adequate

description of them would cover many pages. For this reason, the reader is referred to the following bibliography, which lists publications describing the equipment.

BIBLIOGRAPHY

LOOTENS, C. L., BLOOMBERG, D. J., AND RETTINGER, M.: "A Motion Picture Dubbing and Scoring Stage," *J. Soc. Mot. Pict. Eng.*, **XXXII** (April, 1939), p. 357.

MORGAN, K. F., AND LOVE, D. P.: "Sound Picture Recording and Reproducing Characteristics," *J. Soc. Mot. Pict. Eng.*, **XXXIII** (July, 1939), p. 107.

REISKIND, H. I.: "A Single-Channel Recording and Re-Recording System," *J. Soc. Mot. Pict. Eng.*, **XXVIII** (May, 1937), p. 498.

LOVE, D. P.: "Acoustic Design Features of Studio Stages, Monitor Rooms, and Review Rooms," *J. Soc. Mot. Pict. Eng.*, **XXXVI** (June, 1941), p. 593.

MUELLER, W. A.: "Audience Noise as a Limitation to the Permissible Volume Range of Dialog in Sound Motion Pictures," *J. Soc. Mot. Pict. Eng.*, **XXXV** (July, 1940), p. 48.

AALBERG, J. O., AND STEWART, J. G.: "Applications of Non-Linear Volume Characteristics to Dialog Recording," *J. Soc. Mot. Pict. Eng.*, **XXXI** (Sept., 1938), p. 248.

MUELLER, W. A.: "A Device for Automatically Controlling the Balance between Recorded Sounds," *J Soc Mot. Pict. Eng.*, **XXV** (July, 1935), p. 79.

CRANE, G. R.: "Variable Matte Control (Squeeze-Track) for Variable-Density Recording," *J. Soc. Mot. Pict. Eng.*, **XXXI** (Nov., 1938), p. 531.

HOPPER, F. L.: "Electrical Networks for Sound Recording," *J. Soc. Mot. Pict. Eng.*, **XXXI** (Nov , 1938), p. 443.

"How Motion Pictures Are Made," *J. Soc. Mot. Pict. Eng.*, **XXIX** (Oct., 1937), p. 349.

KIMBALL, H. R.: "Application of Electrical Networks to Sound Recording and Reproducing," *J. Soc. Mot. Pict. Eng.*, **XXXI** (Oct., 1938), p. 358.

WILLIAMS, F. D.: "Methods of Blooping," *J. Soc. Mot. Pict. Eng.*, **XXX** (Jan., 1938), p. 105.

OFFENHAUSER, W. H., JR : "Current Practices in Blooping Sound-Film," *J. Soc Mot. Pict. Eng.*, **XXXV** (Aug., 1940), p. 165.

STROCK, R. O.: "Some Practical Accessories for Motion Picture Recording," *J. Soc. Mot. Pict. Eng.*, **XXXII** (Feb., 1939), p. 188.

LAMBERT, K. B.: "An Improved Mixer Potentiometer," *J. Soc. Mot. Pict. Eng*, **XXXVII** (Sept , 1941), p. 283

READ, S., JR: "A Neon-Type Volume Indicator," *J Soc. Mot. Pict. Eng.*, **XXVIII** (June, 1937), p 633

THE TECHNIQUE OF PRODUCTION SOUND RECORDING

HOMER G. TASKER

Summary.—*Although sound recording differs greatly from motion picture photography, it involves many analogous techniques and some similar processes. Sound recording requires special apparatus to transform sound into energy capable of exposing motion picture film. Its reproduction from the film requires additional transformations involving other specialized apparatus.*

Good sound pick-up on the motion picture set involves acoustic conditioning quite analogous to set lighting, camera angle selection, etc. The sound crew is provided with flexible means for microphone placement and with controls and monitoring devices for observation of the results obtained. The film recording machine is a specialized mechanism requiring precision comparable to that of the motion picture camera. Its operation entails skillful adjustments. The sound department cooperates with the laboratory department in the establishment and interpretation of processing controls.

In discussing the aural or sound problems in the production of motion pictures, three introductory tasks must be undertaken:

(*1*) To distinguish the problems of recording the aural elements of a motion picture scene from those of recording the visual elements.

(*2*) To indicate the scope of production sound recording, as distinguished from scoring and pre-scoring, and from re-recording or sound blending.

(*3*) To introduce, in elementary form, the recording and reproducing apparatus common to all three of these recording activities.

(*1*) As entertainment media, the visual and aural elements of a motion picture scene supplement each other in that sound contributes many details of thought, action, or emotion not possible to the pictorial side and *vice versa*. As media to be recorded upon the motion picture film, they differ in the extreme. The visual element, properly illuminated, is capable of exposing the film directly through the agency of the camera lens, but sound is quite as invisible to the camera eye as it is to the human eye. Hence, it requires very considerable transformations or translations before it can be photographed on the film, and again before it can be reproduced in the theater in a form to be interpreted by the human ear.

Further, the camera and the microphone differ, as do the eye and the ear, in that off-stage objects are almost entirely ignored by the camera, while off-stage sounds are almost as well recorded as the wanted sounds from the scene itself. The limitations thus imposed may be quite severe.

Although the visual and the aural elements both involve time as the very essence of the entertainment values to be recorded, the characteristics of the eye fortunately permit the simulation of continuous motion through the rapid succession of a large number of still pictures, whereas sound requires *absolute continuity* of the recording and of the subsequent reproduction. Fortunately, both these requirements can be met with motion picture film.

Nevertheless, there are many motion picture processes common to sight and sound, for the record of sound is photographic in character, and there is basic similarity between the laboratory processes involved in producing and multiplying these records and those employed for the picture. Moreover, as they leave the studio for projection in theaters throughout the world, they occupy, side by side, the same piece of film.

(*2*) Production sound recording may be defined as the recording of sound that takes place simultaneously with the photographing of the scene. Ordinarily, this includes dialog and such incidentals as footsteps, door slams, and other noises as originate within the camera angle.

Pre-scoring is the prior recording of instrumental or vocal music to be played back during the photographing of a scene to establish musical tempo to which the actors may synchronize their movements. Scoring is the subsequent recording of music to accompany the scene.

Re-recording is the final blending together of the dialog, the pre- or post-scored music, the "character" sound-effects such as crowd murmurs and factory noises, and the effects separately recorded to accompany scenes photographed without sound, *etc.*

(*3*) A great deal has been written about the design and characteristics of sound recording and reproducing equipment but not so much about the nature of the work to be accomplished with these tools or about the techniques involved. The emphasis here will be on the latter rather than on the former features. Details of the equipment may be found in the appended bibliography.

For this reason the basic sound-recording and reproducing system

will be introduced here in quite elementary form. Subsequent references will be made to specific characteristics of certain apparatus as they bear on matters of technique.

Referring to Fig. 1 and beginning at the lower left of the diagram, the essential elements of a sound-recording system are:

(*a*) *Microphone* (*First Transformation*).—Transforms sound energy into electrical energy. Several different types[1,2] are used depending upon the requirements, but each is a high-quality device responsive to the air pressure changes or air particle movements

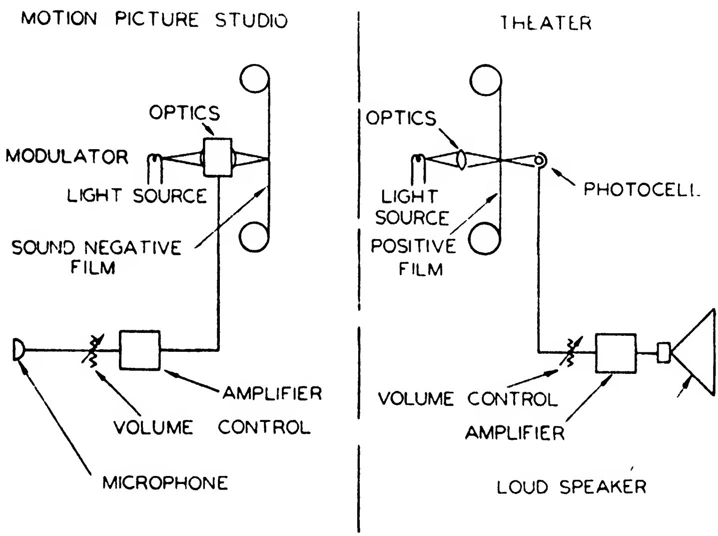


FIG. 1. Elements of sound-recording and reproducing systems.

which characterize sound so that the result is an electrical copy of whatever sound impinges upon the microphone.

(*b*) *Amplifier*.—Increases the above-mentioned electrical energy to usable proportions. The output of the microphone is very feeble. One milli-microwatt is typical, although this will vary with the type of microphone and other circumstances from $^1/_{1000}$ to nearly 1000 times that value. About one watt is needed for recording. Hence the amplification must be very great and must also be of the highest quality and controllable with precision.

(*c*) *Electroöptical Modulator* (*Second Transformation*).—Exposes the sound negative motion picture film under control of the above-

described amplified electrical energy. The motion picture industry is about equally divided in the use of two types of modulators, both of which employ a steady source of light plus electromagnetic means for controlling the amount of this light that reaches the film. In the "light-valve" type of modulator,[3] pairs of metallic ribbons surrounded by a strong magnetic field alternately separate and converge to control the passage of light in response to the amplified current from the microphone. The system is usually so aligned as to expose the sound-track uniformly across its full width but in varying degree along its length, thus producing the "variable-density" type of sound-track. In the "galvanometer" type of modulator[4] the same purpose is served by the rotary oscillation of a small mirror mounted on an electromagnetic structure in such a way as to be responsive to electrical energy. The system is usually so arranged as to expose a fraction only of the width of the sound-track, the magnitude of this fraction varying lengthwise of the film, thus producing the "variable-area" type of sound-track.

(*d*) *Film-Driving Mechanism.*—Moves the film past the exposure point with a very high degree of uniformity of speed.[5,6] It has proved useful to separate the sound recorder from the picture camera. The necessary synchronism is maintained by one of several types of motor systems including a-c interlock,[7] d-c interlock,[8] and synchronous.[8a]

(*e*) *Auxiliary Apparatus.*—This includes such necessary elements as volume controls, fixed or variable equalizers, volume indicators, monitoring equipment, power supplies, *etc.*

Subsequently to the necessary processing of the sound negative and the making of positive prints the equipment necessary to reproduce sound from this film in synchronism with the picture, whether for studio purposes or for projection in theaters, is as follows:

(*f*) *Film-Driving Mechanism.*—Moves the sound-track past the reproducing point with the required uniformity of speed and in synchronism with the picture. In most studio processes the sound-track and the picture are on separate films and the sound-reproducing mechanism is driven by a-c interlock motors or by a "dual film attachment"[9] to the picture mechanism, as the requirements dictate. When released in theaters, a "composite print" is used in which sound and picture are printed on adjacent areas of the same film. In this case, the sound and picture mechanisms are combined, and synchronism is afforded by locating a given picture frame twenty

frames behind the corresponding sound modulation so that they will appear in their respective "gates" of the mechanism simultaneously.

(g) *Optics and Photocell (Third Transformation).**—Produces electrical energy corresponding to the varying optical transmission of the film record. A steady source of light is provided together with an optical system so arranged that light passing through a narrow slit (transversely of the sound-track) reaches the photoelectric cell. As the sound-track moves through the mechanism, the variation in the density or in width of the sound-track exposure causes the required fluctuations in the light falling upon the photoelectric cell.

(h) *Amplifier.*—Increases the electrical energy to useful proportions. The photoelectric-cell output is very feeble under typical conditions. In good theater practice, the amount of sound-modulated electrical energy required to drive the loud speakers varies from 15 to 100 watts, depending upon the size of the theater, *etc.* Hence theater amplifying systems must have not only considerable gain but also quite high output levels with low distortions.

(i) *Loud Speakers (Fourth Transformation).*—In response to the amplified electrical energy, the loud speakers reproduce in the theater sound corresponding to that which originally appeared at the microphone. Simple radio types of loud speakers, even though large in scale, will not serve the requirements adequately. For good results, special high-frequency speakers equipped with multicellular horns are required to afford uniform distribution of intelligibility throughout the theater and to minimize high-frequency distortion. In order to exercise proper judgment in scoring, re-recording, and reviewing operations, similar equipment must be used in the studio.

THE TECHNIQUE OF SOUND PICK-UP

(4) To point a camera at an indoor object, turn on a light, and snap the shutter is one thing. To produce photography having consistent beauty and story-telling power is quite another. It is so with sound. There must be acoustic "lighting" or "conditioning" to obtain the best results. Microphone "placement," like camera "angle," must be carefully worked out.

* The transformations referred to are those mentioned at the beginning as being unique to sound recording and sound reproduction, as distinct from picture photography; hence the film-processing transformations are not numbered among them.

Consider first the problem of intelligibility *vs.* angle, as the actor is photographed from various angles in a given scene. The voice is directional in its frequency characteristic. Forward from the face it is much more brilliant acoustically and carries more intelligibility than toward the rear. Hence, if two actors face each other and the camera shoots over the shoulder of one into the face of the other, and if the microphone takes the same view of the situation as the camera, then the face-on voice will be good but the other will have a muffled yet rather roomy or reverberant quality. Unfortunately, the microphone exaggerates the effect over that observed by human ears in the same location. But even in the absence of such exaggeration, the effect would still be unwanted. A digression is in order to point out why this should be so.

It is not the purpose of alternate angle shots over one shoulder of one actor into the face of a second actor, and *vice versa,* to give an audience the sensation of having been swung back and forth through space to have a look first at one actor and then the other, nor yet that the *terra firma* that supports the actors is performing similar gyrations. On the contrary, if such a scene is well done in all technical respects, the audience should experience no such gyratory effect, but only a snapping of attention from one actor to the other at the instants of greatest interest or of greatest pertinence to the story. The same considerations govern sound recording for such a scene, and accordingly the microphone, though necessarily above the camera angle, should always be in front of and facing the person speaking. This requires extreme mobility of the microphone—mobility available on the instant and accomplished without making noise, without appearing in or casting a shadow on the scene. This demand has led to the development of very excellent microphone booms which afford great freedom of microphone movement and direction, controllable from positions outside the camera angle. By their use the microphone is manipulated into correct position from instant to instant by the "boom" operator under the occasional guidance of the chief sound man or "production sound mixer," who is also controlling other portions of the system and observing the sound quality produced as discussed later.

The type of scene just described consumes a lot of Hollywood film footage each year, but there are, of course, other cases in which the audience should experience special orientation with respect to the scene or should be made aware of such acoustic qualities of the scene

as the reverberation of a cathedral, the hollowness of a cave, *etc.* In other words, the character of the sound sought for by the production sound mixer is always governed by "good theater."

Such effects are rather easier to obtain when wanted than avoided in scenes where they are inappropriate. The microphone is a "one-eared" device, and tends to exaggerate the reflections from walls and other surfaces that give rise to room effects so that the mixer's constant struggle is to reduce them.

The case of strong short-path reflections encountered during close-ups such as at lunch-counters or in other confined spaces is so typical of the mixer's acoustic problems that a close look at this case will illustrate the tools and techniques employed by the mixer for nearly all other cases as well.

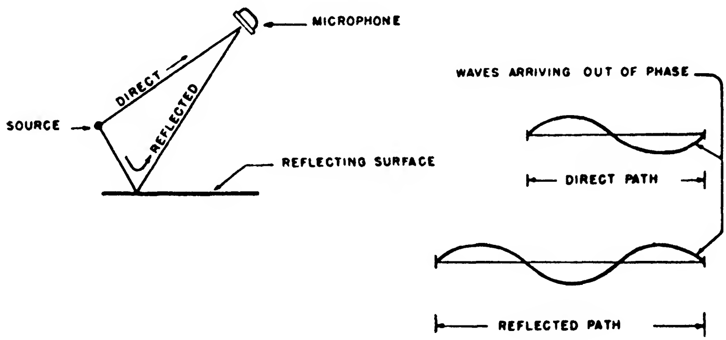


FIG. 2. Interference due to short-path reflections.

The objectionable character of these short-path reflections lies in the fact that they may arrive at the microphone with such strength, due to their shortness of path, that they may nearly cancel the direct sound at certain frequencies or objectionably overemphasize it at other frequencies. As illustrated in Fig. 2, this is determined by the relation of wavelength to difference of path between the direct and the reflected portions.

Such reflections may be reduced during rehearsals by carefully probing the available microphone space to find the spot least affected by the reflections without suffering too much loss of voice brilliance due to unfavorable angle as discussed earlier. The properties of certain recently developed directional microphones[1,2] may also be employed to discriminate somewhat in favor of the direct as against the

reflected sounds but with rather less benefit than might be expected. Fig. 3 illustrates a microphone whose directional properties (see Fig. 4) are adjustable to embrace practically every directional characteristic now attainable. A pressure-responsive unit which is essentially non-directional (see Fig. 4*D*) is mounted in close association with a velocity-responsive element whose polar directional diagram is a pair of circles (see Fig. 4*R*) indicating full response in one axis and zero response at right angles thereto. As may be seen in the intermediate diagrams, these elements may be combined in varying degrees to

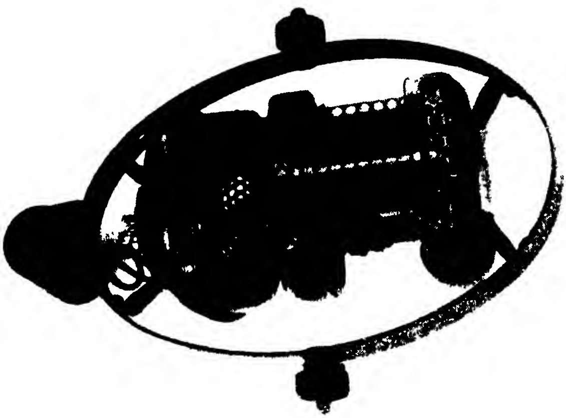
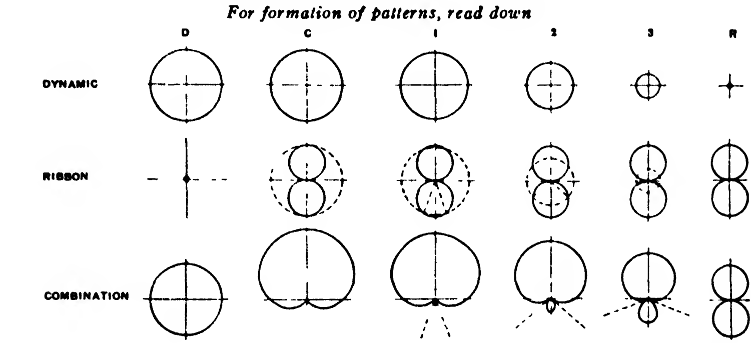


FIG. 3. Unidirectional microphone.

give a variety of response patterns of the general type known as "cardioid."

If now the mixer attempts to use any one of these patterns to discriminate between two sounds differing in angle by as little as thirty-five degrees, as in the example of Fig. 2, then he must choose between having the direct sound arrive at an angle of nearly maximum sensitivity and let the reflected sound be scarcely attenuated, or let the reflected sound arrive at an angle of nearly zero pick-up, which will give excellent discrimination but will always find the direct sound arriving at a point of much less than maximum sensitivity. In the latter case, the major pick-up axis may enhance set noises or smaller reflections from other surfaces to such an extent that these become limiting factors.

The advantages of such microphones are not gained without some penalty. Nearly all microphones are sufficiently bulky and heavy to impair their mobility when swung at a radius of ten to eighteen feet on the modern microphone boom. These "unidirectional" or multi-duty microphones, consisting as they do of a pressure and a velocity microphone combined in one case, always have greater weight and bulk than other microphones of comparable sensitivity.



	D	C	1	2	3	R
DYNAMIC (D) IN %	100	50	46	39	25	0
RIBBON (R) IN %	0	50	54	61	75	100
INDEX I	1	1/3	1/3.2	1/3.8	1/4	1/3
INDEX J	1	1/7	1/9	1/13.7	1/7	1

FIG. 4. Formation of directivity patterns by combinations of ribbon and dynamic microphone elements.

$$\begin{pmatrix}\text{Directivity}\\ \text{Index}\end{pmatrix} I = \frac{\text{efficiency for sound of random incidence}}{\text{efficiency for sound of normal incidence}}$$

$$J = \frac{\text{average efficiency for all angles of sound incidence in rear hemisphere}}{\text{average efficiency for all angles of sound incidence in front hemisphere}}$$

It happens that the strong short-path reflections are most obvious to the ear at frequencies below 1000 cycles. If the mixer has done his best, with the coöperation of the boom operator, to locate a favorable position and orientation for the microphone and still finds himself having reflection troubles, he may be able to effect an improvement by adjusting his low-frequency equalizer or suppressor. If not, he may be able to find a spot favorable to reducing the low-frequency reflections at the cost of some brilliance, but he may be able to restore some of the latter with his high-frequency equalizer. Sometimes, though seldom in this type of problem, he can introduce acoustic absorbing material that will help.[10]

After fighting one of these "lunch-counter" reflections for half a day while the boy and girl finish their coffee and doughnuts, quarrel, kiss and make up, the exhausted sound crew members usually go home resolved that if they ever become writers or producers or executives, there will be no more lunch-counter scenes!

The chances are that next day they may work in a well furnished living-room set that gives no trouble at all; or in a bare tenement bedroom having plenty of "cistern" effect but in which by laying a rug on the floor (out of the camera angle) or by hanging a blanket or two in some area that will not interfere with the lighting, the mixer can get the "feel" of the set about right in his monitor. In general the considerations of time-lag and intensity of reflection in the larger spaces make proper sound pick-up a simpler problem. Of course, when a large "exterior" set must be constructed inside a stage, the stage-wall reflections must be held abnormally low if naturalness is to be achieved. Most sound stages are treated on the inside with two inches of rock wool furred out two or more inches from the solid construction, with the result that the reflections[11] are not objectionable except in the case of exterior scenes. In such cases the sound man is in contact with the job days in advance, learning the camera angles to be used, studying the acoustic problems to be met, planning the treatments necessary, *etc.* Nor does the sound department neglect to develop the coöperation of the art department in shaping structures or choosing material that will minimize the sound-reflection problem.[10]

We have seen then that the mixer's "acoustic lighting" problem is primarily one of avoiding excessive reflections of three distinct types:

(*a*) Confined space or "barrel" reflections.
(*b*) Medium space or "roominess" reflections.
(*c*) Large space or "reverberant" reflections.

To any one of these reflection problems he may apply one or all of the following controls:

(*a*) Proper choice of materials or designs, through coöperation with the art department.
(*b*) Microphone placement.
(*c*) Microphone directional properties.
(*d*) Blanketing to absorb reflections.

Noises occurring within the motion picture set are objectionable except in rare instances when they are in keeping with the character of the action. This is particularly true of such modern noises as

traffic and machinery sounds when the scene being photographed belongs to an earlier period in history. To reduce the penetration of traffic and other external noises, stage walls are heavily insulated,[11] some having attenuations as high as 70 db. Mechanical noises arising within the stage from cameras, wind machines, *etc.*, are reduced by careful design, by elimination of gears, and by the provision of good insulating housings where necessary.[12,13,14] The relative effect of the noises that remain, as compared to the wanted sounds arising from the action, may be further reduced by taking advantage of the directional properties of microphones. Refer again to Fig. 4 for the effectiveness of such microphones in reducing noises of random incidence as compared to direct sounds.

ADDITIONAL QUALITY CONTROL MEASURES

(5) While acoustic considerations and microphone characteristics are of utmost importance to successful sound recording for theater projection, there must also be adequate control of volume. In this respect also it is "good theater" that governs. In actual life, a dance band will produce more than ten million times the sound energy of a quiet scene in a murder mystery. This is a 70-db difference, but if the murder scene were recorded 70 db lower in level than a properly chosen dance band level, the dialog would be completely inaudible in the theater. We must, instead, enable the persons in the back row of the theater to hear the quiet scene distinctly, even though softly, and for this purpose the original 70-db difference in level must be reduced to about 25 db. Hence the mixer must be constantly alert to make the proper volume adjustments of the material he is recording. To this end he is provided with a "unit volume control" for each microphone (normally one to as many as four) plus an inclusive or master volume control. To help him gauge the correct level, he is provided with a volume-indicator meter whose deflections are an indication of the modulation reaching the film. He is provided also with an audible monitoring system, usually a headset of high quality,[15] which enables him to listen critically to the overall result of his work and to apply the judgment that his task demands.

It is true that in the re-recording process some opportunity is afforded for the refinement of the production mixer's work. However, the signal-to-noise ratio of the film (of the order of 55 db) becomes a limiting factor. If the production mixer records a "quiet" original

scene about 15 db lower than he should, then in attempting to correct this error during re-recording, a very objectionable amount of film-surface noise would be introduced. If, on the other hand, a dance band were recorded 10 db too loud, the result would be severe distortions in the recording which could never be corrected. Hence, it is necessary that the production mixer come as nearly as possible to the correct level in the original recording.

Experience has indicated that there must also be considerable adjustment of frequency characteristic[16] to secure proper theater presentation. In some studios this step is reserved solely for the re-recording process. In others, the production mixer makes a first-order correction, leaving refinement to the re-recording mixer.

Having used the foregoing tools and methods in the control of sound and quality to the best of his ability, the production sound mixer must exercise the further control of suggestion and rejection. The most successful mixers develop a high degree of tact and good judgment, knowing just when a word of suggestion to the actor or director will secure a more effective sound recording, and just when sound imperfections are of such importance that they must request additional takes which may cost anywhere from fifty to several hundred dollars.

TECHNIQUE OF FILM RECORDING

(6) In the editing of a motion picture, great advantage is had if the sound record is on a strip of film separate from the picture. It is of further advantage if the sound-recording machine is separate from the picture camera—a practice followed without exception in Hollywood. These two mechanisms must run in synchronism.[8a] In "process" photography shots, a predetermined phase relationship between the camera and the process projector is also involved, and for such shots all studios use some form of a-c interlocking motor system.[7] Several studios use this system for all studio operations and in some cases even for location shooting. Other studios substitute salient-pole synchronous motors for all production shooting except process photography scenes. Neither of these systems is very economical of electrical power and in location work, power-supply takes on considerable importance. For this reason, most studios employ some form of d-c interlock for location work and especially for very light or "super-portable" equipment.[8]

The sound-film recorder, like the motion picture camera, is a highly specialized and very precise piece of mechanism. The design

requirements to secure the necessary uniformity of film motion are adequately discussed in the literature;[5, 6] so also are the requirements and characteristics of the modulators by means of which exposure of the film is produced corresponding to the sound impinging upon the microphone.[3,4] One such system is introduced schematically into Fig. 5 to afford some idea of the operational problems involved.

In this illustration, the pole-pieces of the electromagnetic yoke are cut away and the light-valve ribbons are much enlarged so that their position and action may be clearly seen. Light from the lamp on the

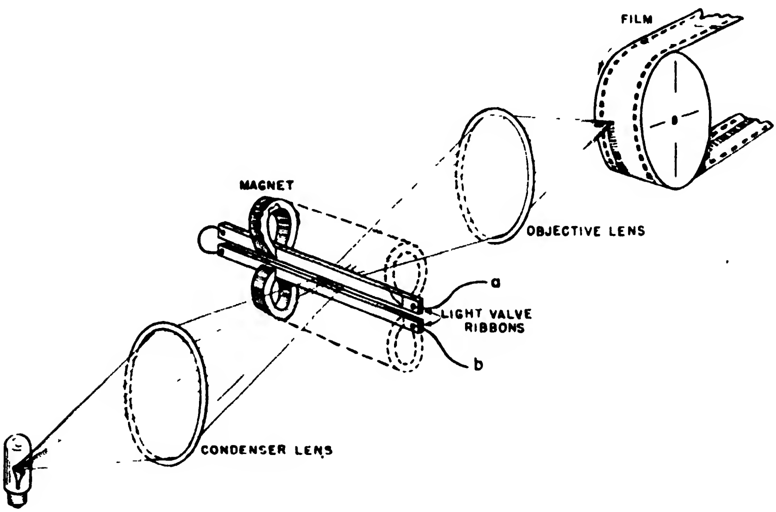


FIG. 5. Light-valve modulator system.

left is spread quite uniformly over the slit between the light-valve ribbons by setting the condenser lens in a slightly out-of-focus position. When a current passes through the ribbons from a to b, the ribbons will separate allowing more light to pass between them, and *vice versa*. The objective lens focuses this light into a thin, sharp line on the motion picture film. If the film were at rest, the intensity of this line would remain constant, but its thickness would vary exactly in accordance with the spacing of the light-valve ribbons; but since the film is moving at a uniform speed of 90 feet per minute, the effect is to vary the exposure lengthwise of the film and hence produce variable-density sound-track. The drum that carries the film is mechanically filtered from the rest of the driving mechanism. Great

care is taken in the design of the mechanical filter, and in some types the variation of speed or "flutter" is held to less than 0.05 per cent of the designated uniform speed.

The light-valve ribbons weigh only two millionths of an ounce each, are about six mils wide and half a mil thick, and must be spaced about a mil apart and accurately parallel. The stringing and adjusting is ordinarily done by a specialist, who also takes care of certain other equipment requiring precise adjustment. In some studios, however, each recordist (recording machine operator) strings and adjusts his own light-valves as required.

During operation, these ribbons are "biased" electrically to a spacing of about $^1/_{10}$ of a mil to effect reduction of film grain-noise by reducing the light reaching the negative. This results in darker exposure of the positive, and hence less reproduced noise during intervals of silence or of low sound level at the microphone.[17, 18, 19] To make the biasing adjustment properly, the recordist must carefully determine the sensitivity of the valve and then adjust the biasing current to the proper amount. The accuracy required is approximately ten millionths of an inch.

In the galvanometer type of modulator, comparable considerations apply, except that in "type *B*" variable-area recording, as practiced at one studio, no noise-reduction amplifiers are involved.

There are many other adjustments of the recording machine and associated equipment that the recordist must make. In addition, he usually starts and stops the entire system on signal from the stage and applies "end strip" exposures for processing control, *etc.*

The sound department must participate actively in the establishment of processing control limits and in the interpretation of the daily results, and must provide the laboratory with most of the specially exposed "strips" that are required. Sound quality controls for processing of variable-density recordings always include sensitometer strips for control of processing gamma. In the case of fine-grain films, which afford considerable improvement in grain-noise and distortion,[20] it is also necessary to make occasional light-valve gamma strips because of the failure of the photographic reciprocity law and the fact that this failure is not uniform with conditions. Most studios also use the newly developed technique of inter-modulation measurement. This method affords a useful means of establishing correct print density for given negative processing conditions.

REFERENCES

(*All references are to J. Soc. Mot. Pict. Eng.*)

[1] HOPPER, F. L.: "Characteristics of Modern Microphones for Sound Recording," **XXXIII** (Sept., 1939), p. 278.

[2] LIVADARY, J. P., AND RETTINGER, M.: "Uni-Directional Microphone Technic," **XXXII** (Apr., 1939), p. 381.

[3] FRAYNE, J. G., AND SILENT, H. C.: "Push-Pull Recording with the Light Valve," **XXXI** (July, 1938), p. 46.

[4] DIMMICK, G. L.: "The RCA Recording System and Its Adaptation to Various Types of Sound-Track," **XXXIX** (Sept., 1942), p 258

[5] KELLOGG, E. W.: "A Review of the Quest for Constant Speed," **XXVIII** (Apr., 1937), p. 337.

[6] ALBERSHEIM, W. J., AND MACKENZIE, D.: "Analysis of Sound-Film Drives," **XXXVII** (Nov., 1941), p. 452.

[7] TASKER, H. G.: "Improved Motor System for Self-Phasing of Process Projection Equipment," **XXXVII** (Aug., 1941), p. 187.

[8] HOLCOMB, A. L.: "Multi-Duty Motor System," **XXXIV** (Jan., 1940), p. 103.

[8a] HOLCOMB, A. L.: "Motor Drive Systems for Motion Picture Production," 42 (Jan , 1944) p. 9

[9] BORBERG, W., AND PINNER, E.: "The Simplex Double Film Attachment," **XXXIV** (Feb., 1940), p. 219.

[10] THAYER, W. L.: "Solving Acoustic and Noise Problems Encountered in Recording for Motion Pictures," **XXXVII** (Nov., 1941), p. 525.

[11] LOYE, D. P.: "Acoustic Design Features of Studio, Stage, Monitor Rooms, and Review Rooms," **XXXVI** (June, 1941), p. 593.

[12] ROBBINS, J. E.: "Silent Variable-Speed Treadmill," **XXXIV** (June, 1940), p 632.

[13] ALBIN, F. G.: "Silent Wind Machine," **XXXII** (Apr., 1939), p 430.

[14] CLARKE, D. B., AND LAUBE, G.: "Twentieth Century Camera," **XXVI** (Jan., 1941), p. 50.

[15] ANDERSON, J. L.: "High Fidelity Head Phones," **XXXVII** (Sept , 1941), p. 319.

[16] MORGAN, K. F., AND LOYE, D. P.: "Sound Picture Recording and Reproducing Characteristics," **XXXII** (June, 1939), p. 643.

[17] SANDVIK, O., AND GRIMWOOD, W. K.: "An Investigation of the Influence of Positive and Negative Materials on Ground Noise," **XXV** (Aug., 1940), p. 126.

[18] KELLOGG, E. W : "Ground Noise Reduction Systems," **XXXVI** (Feb., 1941), p. 137.

[19] SCOVILLE, R. R., AND BELL, W. L.: "Design and Use of Noise Reduction Bias Systems," **XXXVIII** (Feb., 1942), p. 125

[20] DAILY, C. R., AND CHAMBERS, I. M.: "Production and Release Applications of Fine-Grain Films for Variable-Density Sound Recording," **XXXVIII** (Jan , 1942), p. 45

PRESCORING AND SCORING

BERNARD B. BROWN

Summary.—*A brief description of the procedure followed in the Hollywood studios in scoring and prescoring motion picture productions. Scoring is the addition of music and effects after the finish of the photographing; prescoring is the preparation of musical or dance numbers before the photographing.*

PRESCORING

The recording of music for motion pictures is divided into two categories: prescoring and scoring. As the name implies, prescoring means the recording of musical or dance numbers *before* the numbers themselves are actually photographed. At first thought, the idea of recording a sequence prior to photographing it may seem strange; but in actuality there are two very logical reasons for the sound director to do just that: (*1*) We prefer to make these recordings on a stage that has been acoustically treated to make it as perfect as possible for music recording. (*2*) By so doing, we are able to achieve not only fidelity of tone, but also of tempo.

Our first reason is self-explanatory; our second is quickly explained. If we were to record a musical number as the director photographs it, we should be dealing with small sections of music, which when assembled would not be smooth, for the director breaks the sequence up into its component photographic parts, such as long shots, medium shots, close-ups, and various camera angles. It is obviously impossible to play the music at exactly the same tempo each time these short scenes are photographed. Therefore, to do the job correctly the musical number is first recorded on film and on a record, thus insuring that an even tempo will be maintained. It is well to point out that the artist, when making this recording, is free to make all the grimaces and contortions he feels may be necessary to reach

the high notes and pronounce the words clearly, as he is not being photographed while singing for this recording.

The record is then taken to the sound stage and played back to the artist. Here the artist must look his (or her) best, which now is possible because he does not have to think of the singing but only of looking well and synchronizing the lip movement to the record that has already been made. He only has to appear as if he were singing, as the prescored record is used for the final film.

On the scoring stage is a small room, 10 × 10 × 10 feet in size, in which the artist sings. A large window in one of the walls faces the orchestra so that the artist and the musical director can see each other. The singer can hear just enough of the orchestra to assist in singing in tune, but the sound of the singer's voice does not penetrate through to the stage, so the director uses ear-phones bridged into the vocal channel. As soon as a piece has been sufficiently rehearsed, all is ready for a take. The "quiet" signal is given, the stage man signals the recordist to start his machine, the red light flashes, the orchestra plays, the singer sings, and "Take Number One" is made.

The musical number is recorded on two or more separate films and on a wax record which is played back so that the artist and others may hear and criticize the recording. If everyone is satisfied, the "take" is finished; if not, repeat recordings are made until a good one results or until there are enough good parts of several takes to cut together and make one good complete take.

The orchestra and artist may then be dismissed. If after assembling the good parts of several takes the result is not entirely satisfactory, the singer is called back to the scoring stage to re-make all or part of the number. This is done by having the artist sing while listening on a pair of headphones to the orchestra track that has already been recorded. This process saves the studio thousands of dollars a year, since the orchestra is not required for retakes.

When photographing dance numbers the recording that has been prescored is played back and the dancers perform to it. If the number is a tap dance the taps are recorded later on a special dance floor on the recording stage. The dancers are brought in and the picture of the dance that has been photographed is projected. The performers then dance while listening to the music through headphones, and the taps are recorded. The picture has been cut exactly the way it appears in the theater, and the taps match the picture exactly.

SCORING

Scoring is sometimes called "underscoring," which means adding music to the picture after it has been finished. The musical director and his associates view the finished picture with the producer or director, and decide where music can most effectively be used. While the musical director is composing the themes, his assistant is timing the scenes, so as to know how much music to write and at what points it must synchronize with the action.

Where it is necessary to time the music to several definite cues, a "click track" is made, which when reproduced sounds like a metronome. The "clicks" or beats range from one every sixteen frames to as many as one to every four frames. The tempo is determined by the tempo of the scene, and is produced by making a scratch or punching a hole in a piece of blank film at the points where the beats are to occur.

The film is then run on a moviola, along with the picture, and on it are marked the cues in the picture to which the music must be made to fit.

Now that the composer has the length of the scenes and the timing, he composes the music for the picture. The compositions then must be arranged, sometimes by the composer himself and sometimes by professional "arrangers." The arrangement is checked by a musician called a proof-reader, who corrects any mistakes made by the composer or arranger, and the score is given to copyists who copy on separate sheets the music for the different instruments in the orchestra. The proof-reader again checks what the copyists have done, and all is now ready for recording.

The orchestra is seated in a semicircle in front of the director, who stands upon a platform facing the screen and the musicians. The orchestra is arranged in sections with a microphone in each section, as follows, beginning at the left of the director: violins first, then violas and cellos, woodwinds, piano, bass, guitar, and harp, with the brass and the percussion instruments up in back on a separate platform. There are two principal reasons for using this arrangement: One is to provide good compositions and variety in the integrated sounds, just as the cameraman in photographing resorts to long shots, medium shots, and close-ups. The microphones used in the various sections pick up sound from both sides. They are tilted so as to have a close pick-up on one side and a long pick-up on the other side, and thus give good definition, room tone, and scope to the orchestra.

The other reason for using a microphone in each section is to permit the sound director to control the volume from each section by dials on his mixing panel in the monitoring booth. The volume of any section can be increased or decreased, so that if a section is too loud or too soft corrections can be made during the recording and a retake avoided. This saves much time, and time means money in the studio.

The musical director now rehearses the orchestra and at the same time the sound director adjusts his levels on the mixing panel in the monitor booth. When all is ready the recording room is signalled, the picture is flashed on the screen, the orchestra plays, and the director conducts the orchestra while listening to the click track or dialog on a pair of headphones and looking at the picture on the screen behind the orchestra. The process is repeated for each section of music to be used with the picture.

This describes briefly the general processes of prescoring and scoring. A thousand details have been omitted, and it must be emphasized that the processes are not matters of simple routine. Each take has its own problems, and experience and experimentation are as much part of the work as the general routine that has been described.

ILLUMINATION IN MOTION PICTURE PRODUCTION

R. G. LINDERMAN, C. W. HANDLEY, AND A. RODGERS

Summary.—*Illumination of motion picture sets for black-and-white cinematography involves special techniques for the long, medium, close-up, and follow shots, as will the use of booster lights on outdoor sets. Color cinematography requires, in addition, special attention to the color quality of the light and the spectral characteristics of the film. The paper includes a discussion of these requirements and an extensive description of modern lighting equipment.*

When early motion pictures were made, sunlight and skylight were the only sources of illumination. Glass-covered stages were employed for protection against the variables of weather. The only means of light-control were reflectors to re-direct the sunlight, black scrim for diffusion, and opaque mediums to block out undesired rays.

The need of auxiliary lighting of a uniform controllable character made itself evident quite early, and carbon arc lamps, designed for other purposes, were adapted to studio use. These were largely flame-type flood lamps, which added to the general illumination but were not capable of light projection. Later, carbon arc searchlights designed for projecting high levels of illumination into very restricted areas, were introduced.

In these early days several attempts were made to use incandescent lamps, but the restricted color-sensitivity of the film then employed and the absence of high-wattage incandescent bulbs doomed these trials to failure.

The introduction of panchromatic film and new high-wattage constructions in incandescent bulbs, coinciding with the introduction of sound, brought about a major change in motion picture illumination practices.

A desire on the part of cinematographers for accurate light-control brought the condenser-type spotlamp, diverging doors, spill rings, special reflectors, and finally the Fresnel-type lens.

Fresnel-type spotlamps, introduced with both arc and incandescent sources, have had wide acceptance. Except for certain special effects this type, where available, is often used to the exclusion

FIG. 1. Large indoor set showing lighting arrangements for long shot. (*Courtesy Radio Pictures*)

of all others. It furnishes a beam of light which may be varied, by focusing, to provide the desired illumination distribution, with beam divergences of 8 to 48 degrees. Depending upon the size of the equipment, it is used widely for flood-lighting, back-lighting, cross-lighting and modeling. It is ideally suited for use with special control devices described elsewhere in this paper. It also facilitates the use of glass

filters necessary in conjunction with *CP* bulbs to match sunlight or arc light for color.

BLACK-AND-WHITE PHOTOGRAPHY

Although the spectral energy distributions of unfiltered carbon arc and incandescent units vary widely, lights from these sources are freely mixed on sets used for black-and-white photography. Usually the carbon arc is employed where a directional, penetrating source is

FIG. 2 Medium shot. (*Courtesy Warner Bros.*)

required to cut through the general illumination of the set, or where high levels of illumination are needed on background material, including streak light, shadow-producing light, sunlight effects, and masculine characterization.

Incandescent units are used for broad illumination, and where smallness and lightness of weight are important, particularly on medium-size sets where high light levels are not indicated. On small and medium-size sets many cinematographers use incandescent units almost to the exclusion of carbon arcs, whereas others mix arcs and incandescents freely. On large sets most cinematographers use mixed

sources. For close-ups the incandescent is usually indicated for soft, feminine effects, whereas the arc is often used for masculine characterization and to produce extreme gradations of illumination.

In the preliminary arrangement of lighting equipment the chief set electrician, under the direction of the director of photography, sets in place the floor and overhead units. The director of photography establishes the "key-light," which is directional illumination meas-

FIG. 3 Black-and-white close-up. (*Courtesy Paramount Putures*)

ured near the face of the principal character, and then rearranges reduces, or intensifies the illumination falling upon other areas to achieve the desired balance. "Balance" is largely an artistic or dramatic rather than a strictly technical effect.

Although illumination meters are in common use by cinematographers, the chief set electrician ordinarily does not use them. His problem is to arrange the various pieces of equipment, such as lamps, diffusers, dimmers, *etc.*, so that the cinematographer may establish a "balance" in a minimum of time. The placement of this equipment depends upon the experience of the chief set electrician, his

knowledge of the desires of the director of photography, and the advance conferences that take place before the set is rigged.

The Long Shot.—Fig. 1 shows the overhead and part of the floor lighting equipment for a black-and-white long shot. The lamps are placed high on parallels around the walls of the set, behind doorways and windows, on backings, and on the floor in the foreground.

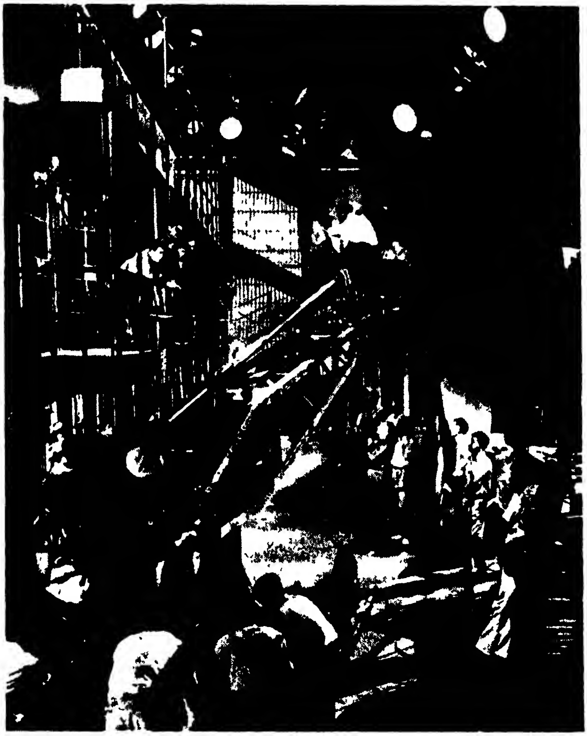


FIG. 4. Follow shot. (*Courtesy Warner Bros.*)

The Medium Shot.—When the camera equipment is moved in for a medium shot (Fig. 2) the floor-lighting equipment is moved forward and some of the overhead lamps are re-directed. Usually no major changes are necessary in the location of overhead and back-lighting units.

The Close-Up.—This shot (Fig. 3) is also accomplished by rearrangement of the front floor-lighting units and the re-direction of overhead lighting equipment.

Follow Shot.—On the follow shot (Fig. 4) the camera follows the action around the set or even from room to room. The technique of lighting for this kind of shot requires very close coöperation between the director of photography and the electrical crew. The entire area of travel must be illuminated properly, and it is often necessary to raise or lower the illumination levels in certain areas during the actual shooting. This is accomplished by placing dimmer banks in stragetic locations and by cueing the operators (Figs. 5 and 6).

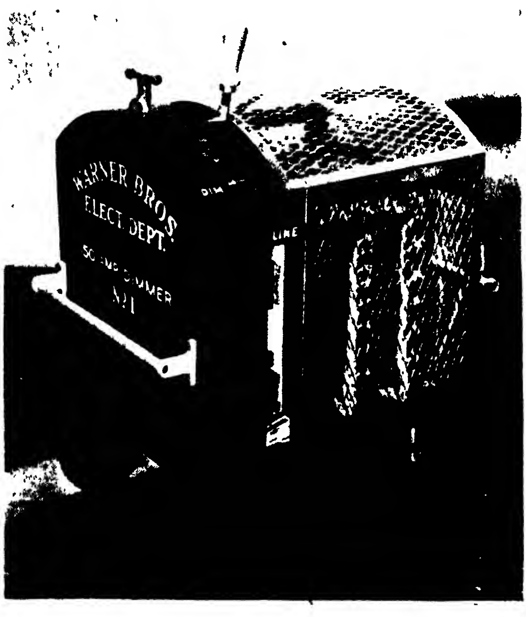


FIG. 5 Dimmer bank.

Booster-Lights.—On outdoor daylight shots (Fig. 7) lamps are often used to illuminate important areas blocked from receiving sunshine or skylight. The action is then not limited to areas having sufficient natural illumination.

COLOR PHOTOGRAPHY

Color photography is more exacting than black-and-white photography. The white-flame carbon arc matches the quality requirements of three-color photography. The rotating high-intensity

arcs and incandescent tungsten sources must be filtered to provide the required quality. In black-and-white photography variations of quality and quantity of illumination result only in differences in shades of gray. In color photography, variation in quality will change the colors, and low levels of illumination, which in black-and-white photography result only in obscuring shadows, will often change the appearance of background, costumes, or features. For example,

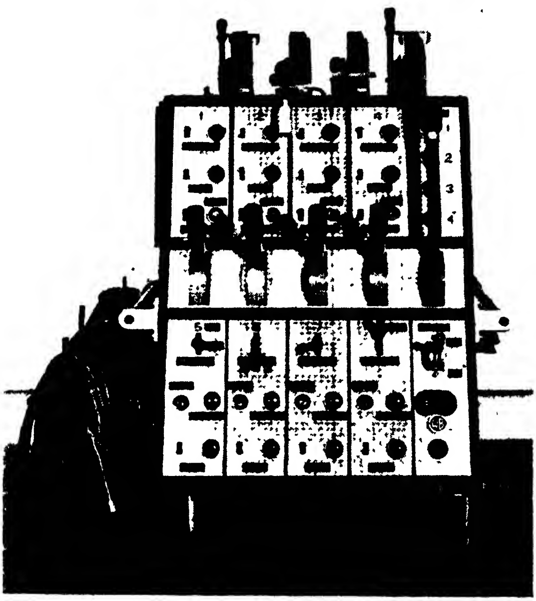


FIG 6. Dimmer bank.

if a colored velvet gown were improperly illuminated the folds might go black, with the result that the costume would appear as a colored gown with black stripes.

For this reason, whereas the illumination meter is used in black-and-white photography chiefly to establish the "key-light," in color photography it finds wider use in that both shadow and highlight levels are usually measured. Much of the equipment arrangement technique that applies to black-and-white photography applies also to color photography, the major exceptions being that higher levels

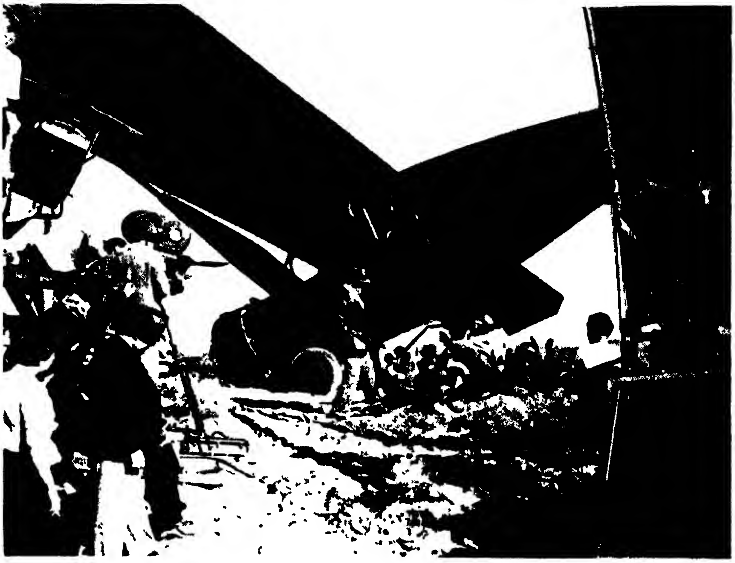


FIG. 7. Black-and-white booster shot. (*Courtesy Warner Bros.*)

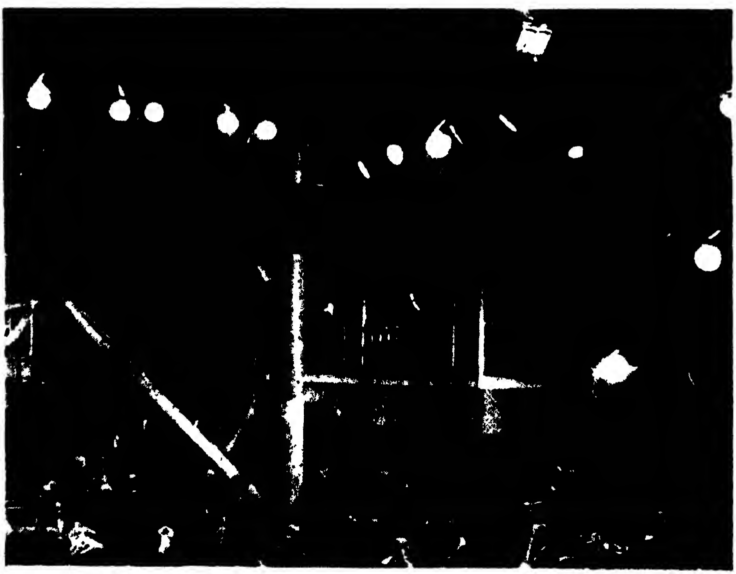


FIG. 8. Color long shot.

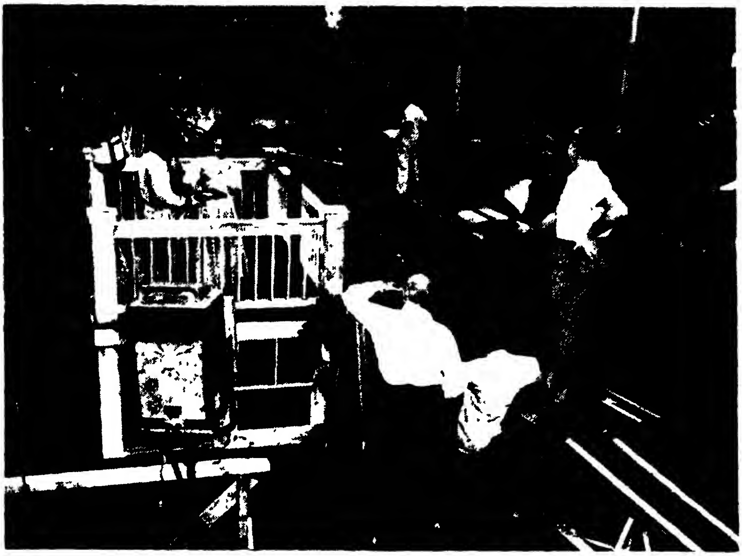


FIG. 9. Color medium shot (*Courtesy Paramount Pictures*)

FIG. 10. Color close-up. (*Courtesy Paramount Pictures*)

FIG. 11. Color follow shot (*Courtesy Paramount Pictures*)

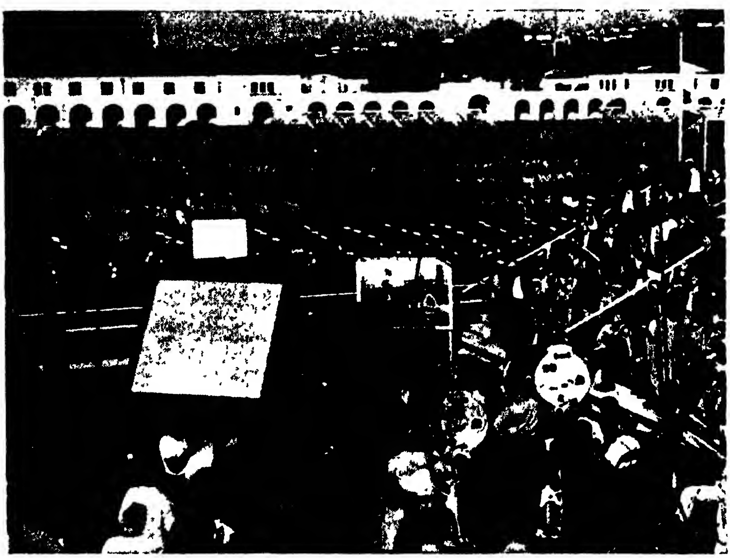


FIG. 12. Color booster light shot. (*Courtesy 20th-Century Fox*)

are required for color and the quality of the illumination must closely approximate average sunlight.

Inasmuch as the white-flame arc approximates sunlight in quality and a greater quantity of illumination is available from a single source, the carbon arc is the most generally used source of illumina-

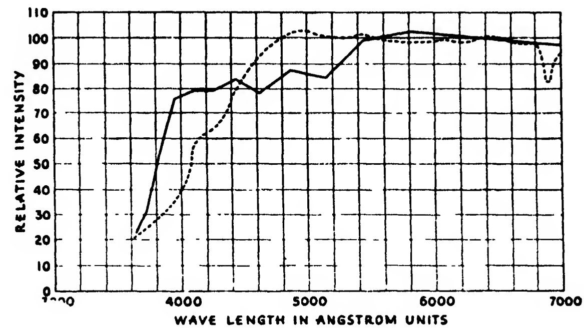


FIG. 13. *Solid line:* Spectral energy distribution, 8-mm–7-mm *MP* studio carbons at 37 volts, 40 amperes *Dotted line:* Spectral energy distribution, solar radiation at sea level

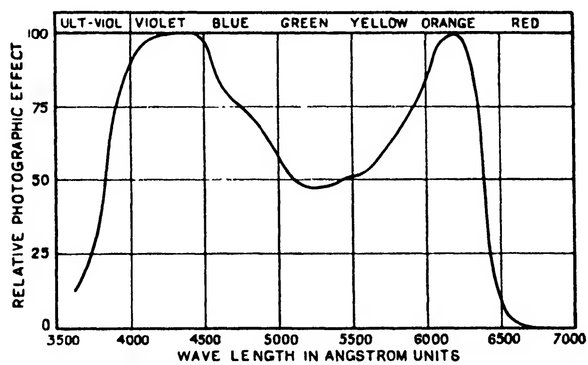


FIG. 14. Photographic effect of light on film.

tion for color. The number of incandescent units mixed with carbon arcs on a color set depends upon the artistic and dramatic requirements from the viewpoint of the director of photography. Figs. 8, 9, 10, 11, and 12 show the color long shot, medium shot, close-up. follow shot, and booster light shot.

MODERN CARBON ARC LIGHTING

Modern developments both in carbons and in lamps have adopted the carbon arc lighting most effectively to the needs of the studio,

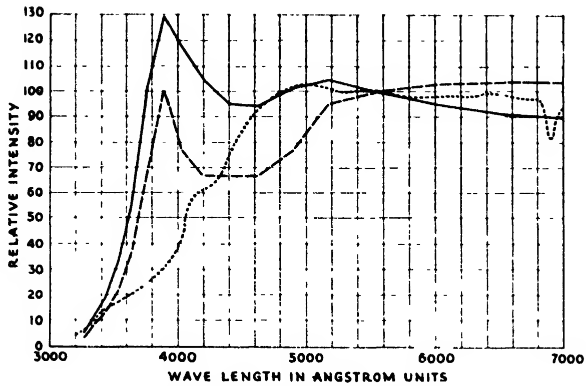


FIG. 15. *Solid line:* Spectral energy distribution, 9-mm H.I. carbon arc at 49 volts, 70 amperes—through glass. *Dashed line:* Same, through glass and *Y-1* filter *Dotted line:* Spectral energy distribution, solar radiation at sea level

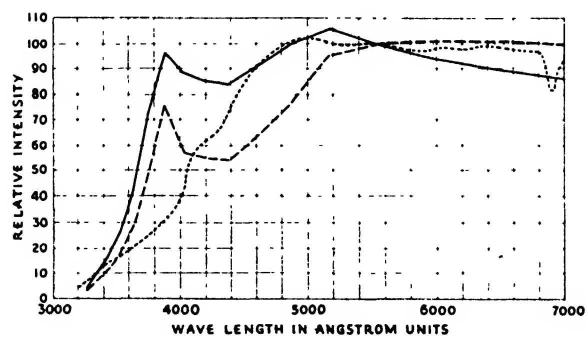


FIG. 16. *Solid line:* Spectral energy distribution, 13.6-mm H.I. carbon arc at 63 volts, 115 amperes—through glass. *Dashed line:* Same, through glass and *Y-1* filter. *Dotted line:* Spectral energy distribution, solar radiation at sea level.

particularly for color photography. The radiation through glass from the special motion picture studio carbons developed for use in broadside lamps resembles sunlight so closely that it can be mixed with sunlight on color productions without the use of color-correcting filters. The solid line in Fig. 13 shows the energy distribution so

obtained from these carbons and, for comparison, the energy distribution of solar radiation at corresponding wavelengths. The peak of radiant energy at about 3900 Angstroms, commonly known as the "cyanogen band" and usually considered characteristic of the carbon arc, is suppressed in the radiation from this arc due to the selection of a relatively low arc voltage. The solar radiation curve is drawn from data recommended by Parry Moon for use as the standard solar radiation near sea level.[1]

The photographic effect of a light-source is determined by three factors: intensity of radiation from the source, transmission of the

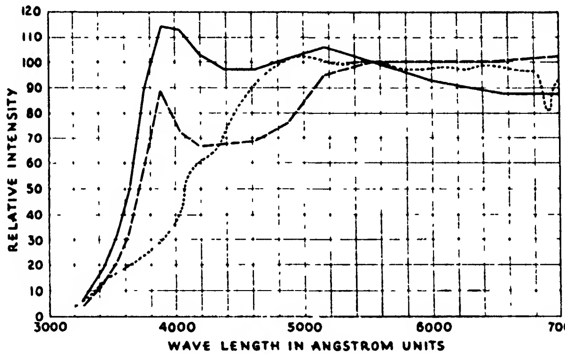


FIG. 17. *Solid line:* Spectral energy distribution, 16-mm H.I. carbon arc at 81 volts, 150 amperes—through glass. *Dashed line:* Same, through glass and *Y-1* filter. *Dotted line:* Spectral energy distribution, solar radiation at sea level.

camera lens, and the sensitivity of the photographic film. Since each of these characteristics varies with color or wavelengths, photographic effect is best defined by a curve representing the products of these three factors at various wavelengths. The photographic effect of the light from the motion picture studio carbons, previously mentioned, recorded on panchromatic film* of the type used in the studios for negative production, is shown by the curve in Fig. 14. Data for this curve were obtained by multiplying values of illumination at various wavelengths, as shown in Fig. 13, by corresponding values of the transmission of the lens and the sensitivity of the film. The vertical scale of this curve is adjusted to a maximum of 100.

* Eastman Plus-*X* Type *1231*.

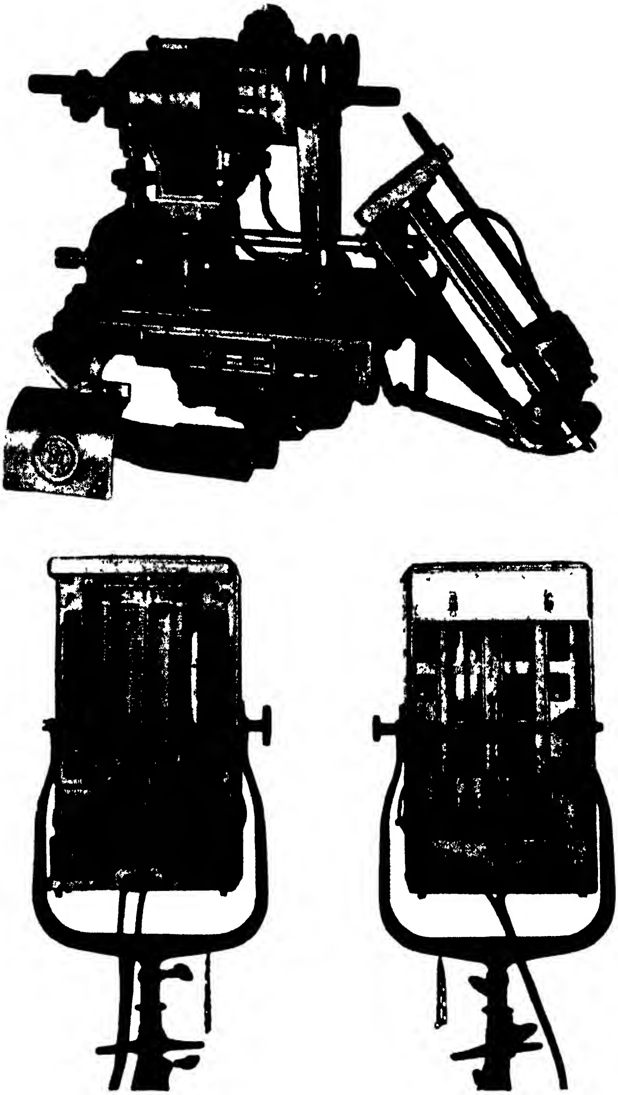


FIG. 17(*A*). (*Upper*) Typical carbon arc high-intensity rotating element (*Lamps Nos. 4, 5, 6, 7, 8, 9*). (*Lower*) Two views of *M-R* Type *40* Duarc broadside carbon arc mechanism (*Lamp No. 3*).

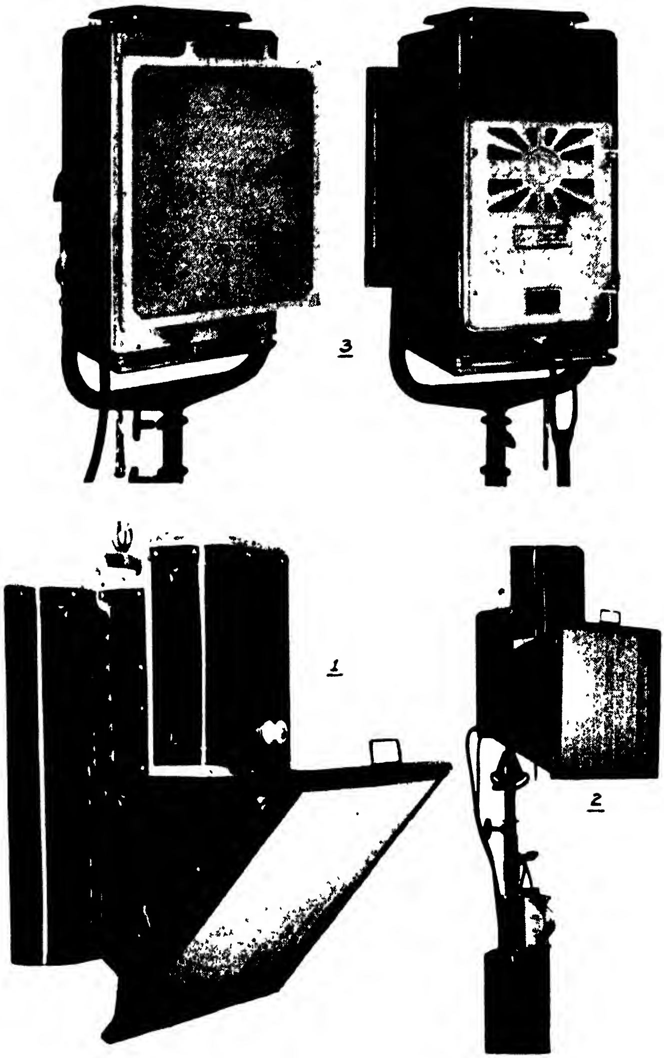


FIG. 17(*B*). *Lamp No. 1: M-R* Type *27* scoop. *Lamp No. 2: M-R* Type *29* broadside. *Lamp No. 3* (*Front and rear views*): *M-R* Type *40* Duarc broadside.

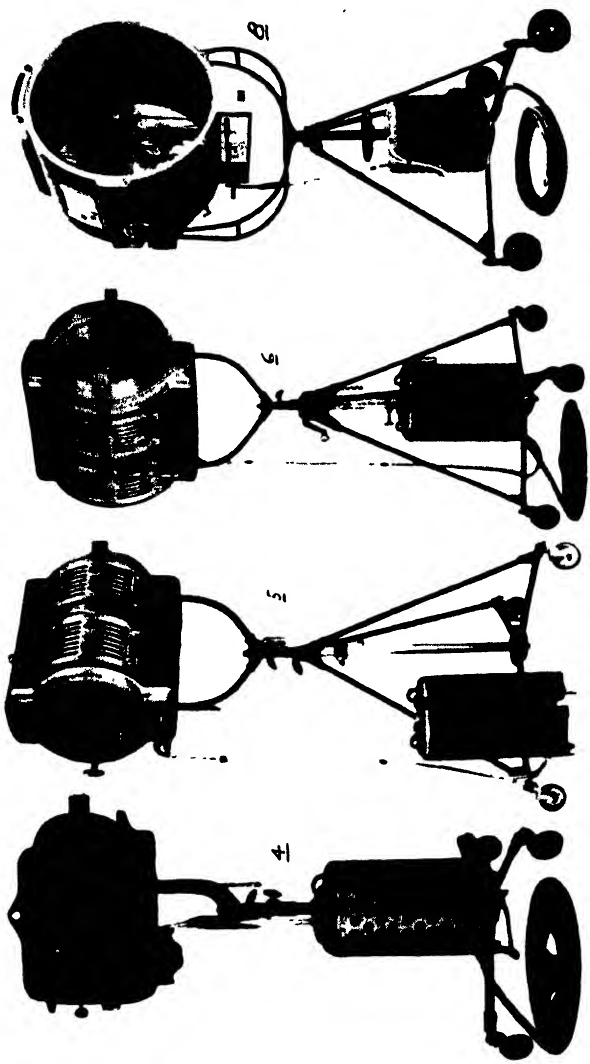


FIG. 17(C) *Lamp No 4*: *M-R* Type *65* arc spotlamp *Lamp No. 5*: *M-R* Type *90* arc spotlamp. *Lamp No 6*: *M-R* Type *170* arc spotlamp *Lamp No. 8*: 36-inch sun arc.

Note that the photographic effect in the red range differs little from that in the blue.

Radiation from the high-intensity carbon arcs used for studio lighting is, relatively, somewhat stronger in violet and blue components than that from the motion picture studio carbons. However, a light straw-colored filter (*Y-1*)[2] is sufficient to correct this difference and give substantially the same spectral balance and photographic effect as obtained from the motion picture studio carbons. The solid line in Fig. 15 shows the spectral energy distribution through glass from the 9-mm high-intensity carbon arc at 49 volts and 70 amperes. The dashed curve shows the distribution through glass and the *Y-1* filter. In similar manner, Fig. 16 shows the distribution from the 13.6-mm high-intensity carbon arc at 63 volts and 115 amperes, and Fig. 17 the distribution from the 16-mm high-intensity arc at 81 volts and 150 amperes.

Following are descriptions of several types of carbon arc lamps now in general use in motion picture studios.

CARBON ARC LAMPS

Figs. 17(*A*), (*B*), and (*C*) show some of the various types of lamps in the following list.

(*1*) *M-R Type 27 Scoop.* Chromium-plated reflector and Factrolite glass diffuser; solenoid controlled. A twin-arc flood source, used for overhead illumination of walls, backings, and other areas that can not be lighted satisfactorily by spotlamps. Suspended singly or in groups. A smooth, general-purpose light-source.

(*2*) *M-R Type 29 Broadside.*—Chromium-plated reflector and Factrolite glass diffuser; solenoid controlled. A twin-arc-flood source that may be raised, lowered, and tilted, and used as a floor-lighting unit for building up front light to the desired exposure level.

(*3*) *M-R Type 40 Duarc Broadside.*—Chromium-plated reflector and pebbled, sand-blasted pyrex glass diffuser. An improved motor-controlled twin-arc flood-lamp that takes the place of both scoop and broadside of the older types.

(*4*) *M-R Type 65 Arc Spotlamp.*—Eight-inch diameter Fresnel-type lens; high-intensity rotating mechanism. Used for front and back-lighting, close-up, and medium shots. The intensity is almost uniform in the main portion of the beam, tapering off at the edges to permit overlapping adjacent beams without producing a zone of

objectionably high intensity. Within its energy capacity this lamp may be used for all photographic spot lighting.

(5) *M-R Type 90 Arc Spotlamp.*—Fourteen-inch diameter Fresnel-type lens; high-intensity rotating mechanism. Used for back-lighting, sunlight effects through doorways or windows, *etc.*, for key-lighting on sets of moderate size, and for general front lighting into the rear areas of deep sets.

(6) *M-R Type 170 Arc Spotlamp.*—Twenty-inch diameter Fresnel-type lens; high-intensity rotating mechanism. Used for back-, cross-, and key-lighting, and for wide- and narrow-angle front and effect lighting. This unit has wider use in both black-and-white and color photography than any of the other arc units.

(7) *24-Inch Sun Arc.*—Twenty-four inch diameter glass mirror; high-intensity rotating mechanism. Normally used with the arc crater facing the mirror and a clear glass door on the front of the lamp-house. Where very sharp shadows are necessary the clear glass door may be moved to the position normally occupied by the mirror. A metal door is then placed on the open end. A large number of these lamps have been converted to use the same optical system as the *M-R Type 170* lamp. Used for back-lighting, sunlight effects through windows and doorways, *etc.*, for key lighting on sets of moderate size, and for general front lighting into the rear areas of deep sets.

(8) *36-Inch Sun Arc.*—Thirty-six inch diameter glass mirror; high-intensity rotating mechanism. Similar to the 24-inch Sun Arc except as to size. The 24-inch Sun Arc is rapidly being converted to the Fresnel type of lens, but due to its great penetrating power, the 36-inch Sun Arc is valuable for extremely long throws and retains its popularity in its present form. When a large quantity of diffused light is required from this unit, a diverging door composed of strips of cylindrical lenses replaces the plain glass door. The lamp is used where a very great illumination is required, as in back-lighting behind a high level of foreground illumination; or where well defined shadows are required; or where a clearly defined streak of light is required through the general illumination; or for producing a general illumination of great penetration and high intensity.

(9) *80-Ampere Rotary Arc Spotlamp.*—An 8-inch diameter plano-convex condenser or 12-inch Fresnel-type lens; high-intensity rotating mechanism; one of the early high-intensity arc spotlamps. This lamp in its present form is not suitable for color because of the spectral energy distribution of the carbon trim. A number of these

lamps have been converted to the use of 11-mm × 20-inch high-intensity motion picture studio positive carbons to make them suitable for color photography. They are used for back-lighting on black-and-white sets.

INCANDESCENT LIGHTING

The incandescent lamp is essentially a piece of tungsten wire heated to incandescence in a glass bulb filled with an inert gas to retard the

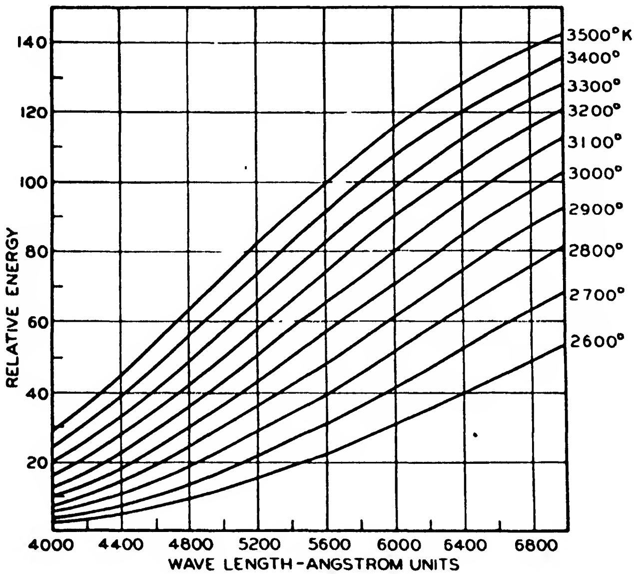


FIG. 18. Spectral energy distribution in the visible region from tungsten filaments of equal wattage but different temperatures.

evaporation of the tungsten. The radiation gains in quantity and becomes whiter with increasing filament temperature. In Fig. 18 each curve indicates the relative radiant energy throughout the visible spectrum emitted by an incandescent lamp filament of a given color-temperature. Note the values of the upper and lower curves at the wavelength of 4000 Angstrom units, which is near the limit of visible light in the violet. The value of the upper curve at this point is about ten times that of the lower curve. Compare this with the increase at 7000 Angstroms, near the upper limit of visible red. Here the upper curve has risen less than three times the value of the lower

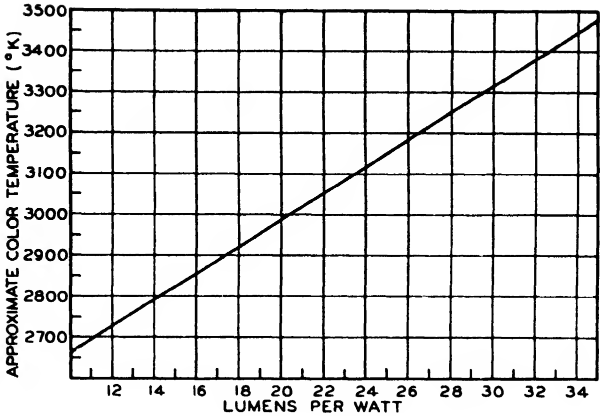


FIG. 19. Approximate relationship of color-temperature to efficiency for standard voltage Mazda "C" lamps

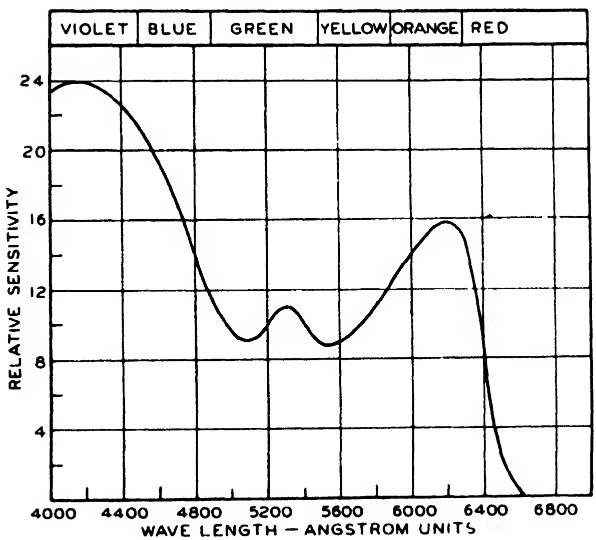


FIG. 20. Relative sensitivity of photographic film *vs.* wavelength of radiation.

curve. This fact is important in any photochemical process, since most photographic materials are more sensitive to radiation in the blue-violet. The higher the color-temperature of the filament, the more photographically effective is the light.

Fig. 19 shows the increase in efficiency of Mazda *C* (gas-filled) lamps with increasing color-temperature, measured in terms of lumens per watt. The total light output of all incandescent lamps is measured in lumens, and the data are published in standard lamp catalogs and literature. Fig. 19 therefore provides a handy means of determining the approximate color-temperature of any lamp by dividing the number of lumens by the wattage. This is of particular interest to those using other than standard light-sources in color photography.

TABLE I

Arc Lamps for Set Lighting

Lamp No	Unit	*Degrees Beam Divergences		Positive Carbon No.	Negative Carbon No.
		Min	Max		
1	*M-R 27* scoop[3]	90	90	1	10
2	*M-R 29* broadside[3]	90	90	1	10
3	*M-R 40* broadside	90	90	1	16
4	*M-R 65* spotlamp[2]	8	44	2	11
5	*M-R 90* spotlamp[4]	8	44	5	14
6	*M-R 170* spotlamp[5]	8	48	6	15
7	24-inch sun arc[5]	**10	24	6	13
7A	24-inch sun arc (converted)	8	48	6	15
8	36-inch sun arc[2,5]	10	32	6	13
9	80-amp rotary spot[6]	**8	30	4	12
9A	80-amp rotary spot (converted)	8	44	3	12

* Approximate figures referring to usable photographic light.
** With Fresnel-type lens divergences are approximately 8 to 44 degrees.

In photography we are more interested in the photographic effectiveness of the light than in its visual effect, and photographic effectiveness depends upon the type of film used. Fig. 20 shows the curve of relative sensitivity to radiation at various wavelengths in the visible spectrum, characteristic of a typical panchromatic motion picture production negative film.* By multiplying the sensitivity values given by this curve at various wavelengths by the relative energy values given by Fig. 18 for the same wavelengths, the family

* Data given are for Eastman Plus-*X* Type *1231*.

of curves shown in Fig. 21 is obtained. Fig. 21 provides a picture of the relative photographic effectiveness throughout the visible spectrum for light-sources of equal wattage and various color-temperatures for this particular type of film.* Note that with rising color-temperatures the values at the blue-violet end of the spectrum are increased in greater proportion than those at the red-orange end. Fig. 22 illustrates the improvement in photographic effectiveness with lamps of equal wattage, by increasing color-temperatures, for the Panchromatic film in question.

TABLE II

Carbons for Set Lighting

Carbon No.		Amperes	Arc Volts
	Positive Carbons		
1	8-mm × 12-inch NP *MP* studio[5–9]	38–43	35–40
2	9-mm × 20-inch Hilow projector[9, 10]	65–70	52-54
3	11-mm × 20-inch HI *MP* studio[9]	90–95	62-65
4	1/2 × 12-inch 80-amp rotary spot[5, 7–9]	75–80	50–55
5	13.6-mm × 22-inch HI projector[2, 9, 10]	110–115	54–56
6	16-mm × 20-inch HI *MP* studio[2, 5, 7–10]	140–150	64–67
	Negative Carbons		
10	8-mm × 12-inch NP *MP* studio		
11	7-mm × 9-inch cored Suprex negative		
12	3/8 × 9-inch cored 80-amp rotary spot negative		
13	11-mm × 10-inch plain-cored *MP* studio negative		
14	7/16 × 8 1/2-inch *MP* studio negative		
15	1/2 × 8 1/2-inch *MP* studio negative		
16	7-mm × 9-inch NP *MP* studio negative		

Theoretically, this increase in photographic efficiency of the light-source is limited only by the melting point of the tungsten filament at about 3655°K. Practically, it is necessary to design for an efficiency somewhat below this value, as the life of the lamp becomes uneconomically short at the extremely high color-temperatures. At present the highest practicable efficiency is obtained with the photoflood lamps which operate between 3400°K and 3500°K. Therefore, the practical design of an incandescent lamp for photographic purposes involves a compromise between efficiency, life, size of bulb, necessary additional equipment, and cost of operation.

* Note that the curves for incandescent filament light-sources do not extend below 4000 Angstroms. They are therefore useful only for other incandescent filament sources or for determining the photographic effectiveness of visible light.

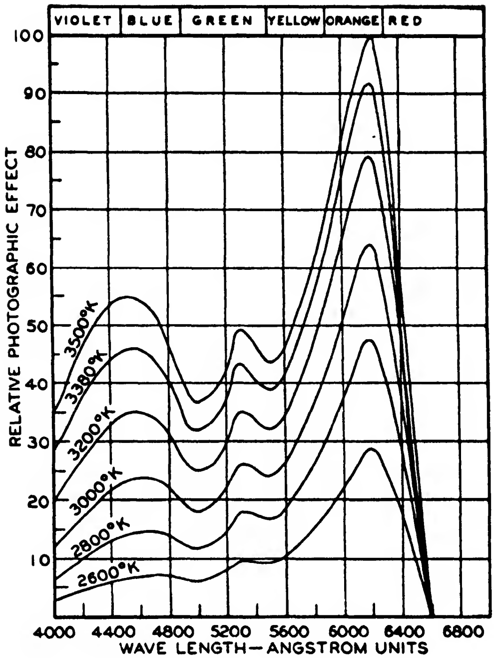


FIG 21. Relative photographic effectiveness of light-sources of equal wattage and various color-temperatures.

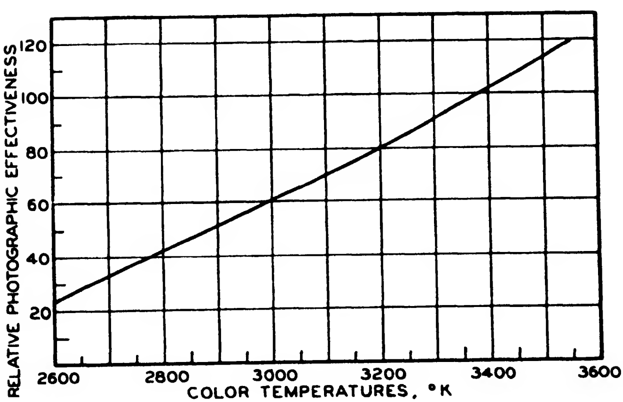


FIG. 22. Photographic effectiveness of tungsten filament lamps of equal wattage and different color-temperatures. (Typical M. P. production film.)

By designing lamps to operate at high color-temperatures, high efficiency and good actinic quality are gained. The bulbs can be comparatively small in size, and the equipment can therefore be relatively small and easily applied and handled. However, these benefits are gained at some sacrifice in the life of the light-source. For longer life the efficiency must be lower and the size of bulbs and equipment larger, or more equipment must be used for a given photographic value.

As the wattage of a lamp is increased the tungsten filament becomes thicker and does not evaporate to the point of failure so quickly,

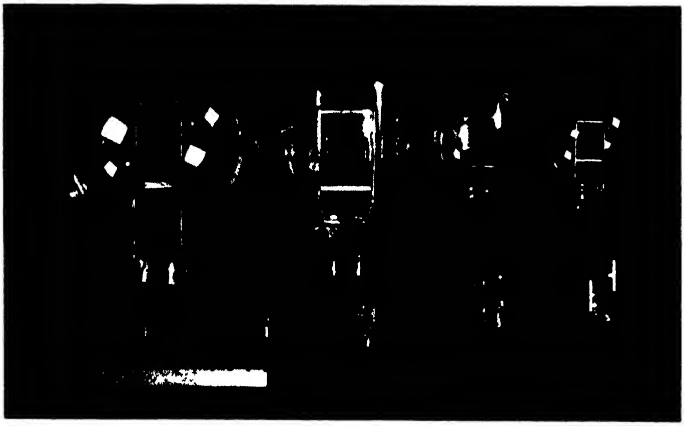


FIG. 23 *MP* and *CP* lamps listed in Table IV

which explains why, at a given color-temperature, the life of higher-wattage lamps is considerably longer than that of lower-wattage lamps.

For black-and-white motion picture photography the practice has been to design the light-sources for a particular length of life, usually between 50 and 100 hours. Such lamps are *MP* lamps, and are listed in Table IV. Since they are designed with respect to life, the color-temperatures vary over a range of approximately 400°K. This results in high-wattage lamps, which are relatively more efficient and produce higher color-temperatures than the lower-wattage lamps.

For color photography the major consideration is to have light of substantially the same color-quality from all sources. For this pur-

pose, a second group of lamps, designated *CP* lamps, also shown in Table IV, is designed for a particular color-temperature. Here the higher-wattage lamps have longer lives than the lower-wattage lamps because the heavy filaments do not evaporate as rapidly. Note that in the case of the 5-kw and the 10-kw sizes the characteristics of the *CP* and *MP* lamps are identical. For this reason it has become possible to design a single lamp in each of these two wattages that is correct for both black-and-white and color photography when operated at the rated voltage. The *MP* and *CP* lamps listed in Table IV and illustrated in Fig. 23, form the backbone of modern studio lighting practice. They fall logically into four wattage groups,

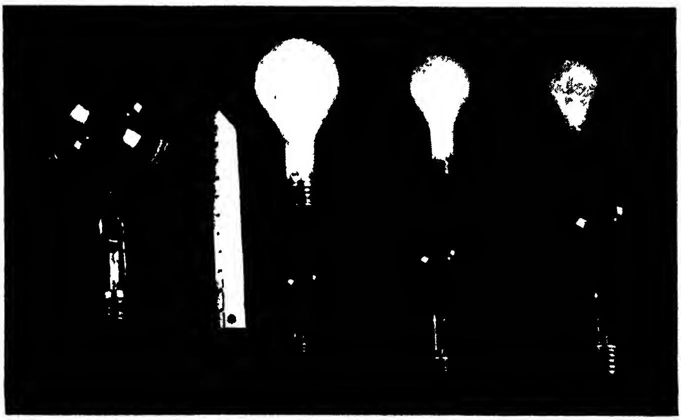


FIG. 24 General service lamps used in broads and floodlights.

with two lamps in each group suitable for a particular size of equipment to fill a specific need. The 10-kw lamp is a possible exception, requiring larger equipment. This standardization of light-sources and equipment greatly simplifies the problem of set lighting.

Most professional color motion picture processes are balanced to a color-quality approximating that of average daylight. Special color-filters are available for use with the *CP* lamps to filter out the proper proportions at the red-orange end of the spectrum to adapt the light to such processes. If lower color-temperature lamps were used the filter necessarily would have to absorb greater quantities of red and orange light, and the overall efficiency would be very low.

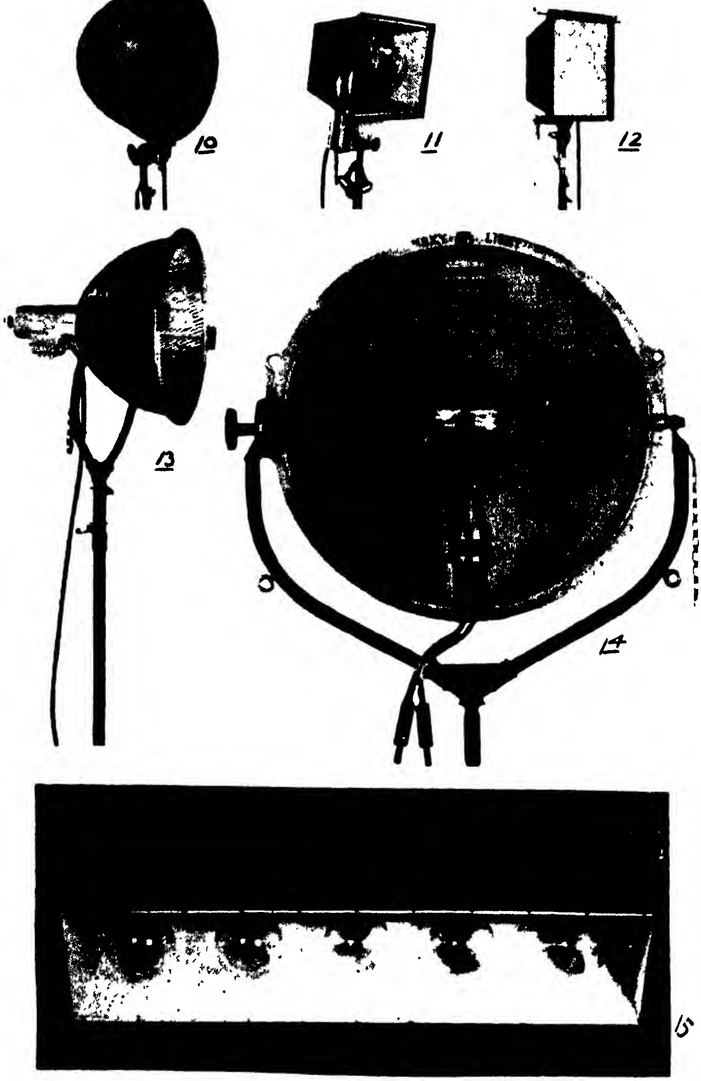


FIG. 24(*A*). *Lamp No. 10: M-R* Type *16* Cinelite. *Lamp No. 11:* Broadside (doubles), *M-R* Type *20*. *Lamp No. 12:* Broadside (singles). *Lamp No. 13: M-R* Type *45* rifle lamp. *Lamp No. 14:* Sky light. *Lamp No. 15:* Overhead strip light.

For Technicolor photography, an approved filter, such as the *Whiterlite* filter, must be used with the *CP* lamps.

In many instances high-efficiency bulbs of the shape and appearance of general service lamps are used in "broads" and floodlights. Table IV lists the lamps available for such purposes, and the lamps are illustrated in Fig. 24. The daylight blue photofloods may be used as supplementary light-sources for color processes balanced to daylight. The smaller lamps in this group are often used as "practical" lamps, concealed in lighting fixtures and behind objects on the set. Small standard projection lamps also are often used in lighting fixtures as "practical" lamps.

Average Life.—Although a given type of lamp is designed for a particular laboratory life, obviously they will not all burn out at exactly the same time, but the majority of them can be expected to fail close to the rated time.

Initial Lumens.—All lamps are rated according to their initial light output. The output decreases somewhat throughout life due to blackening of the bulb by tungsten evaporated from the filament. In gas-filled lamps the majority of the blackening occurs on the glass directly above the filament, and is due to currents of gas carrying the tungsten particles upward. In the 10-kw and 5-kw lamps, considerable blackening may occur in time, and for this reason a small quantity of granulated tungsten is provided in the bulb. After approximately each 10 hours of use, the lamps should be removed from the socket and the tungsten powder swirled about in the bulb, cleaning off the blackening and restoring the efficiency to nearly the original value. This tungsten powder is also provided in the 2-kw *T-48* or *G-48* mogul bipost *MP* lamps.

Voltage Rating.—In general, the photoflood and movieflood lamps are rated at 105–120 volts. The data on wattage, color-temperature, light output, and life of these lamps apply to their use at 115 volts. The *MP* lamps are usually supplied in the 120-volt class as this is the voltage available in most studios. However, when the supply lines to the sets are heavily loaded the voltage is usually closer to 115 volts. For that reason the *CP* lamps are ordinarily supplied in the 115-volt class as it is extremely important that the color-temperature be maintained at 3380°K. Also at this voltage the color-temperature will match that of the photoflood and movieflood lamps.

A drop of 1 volt below the voltage rating of the lamp will cause a

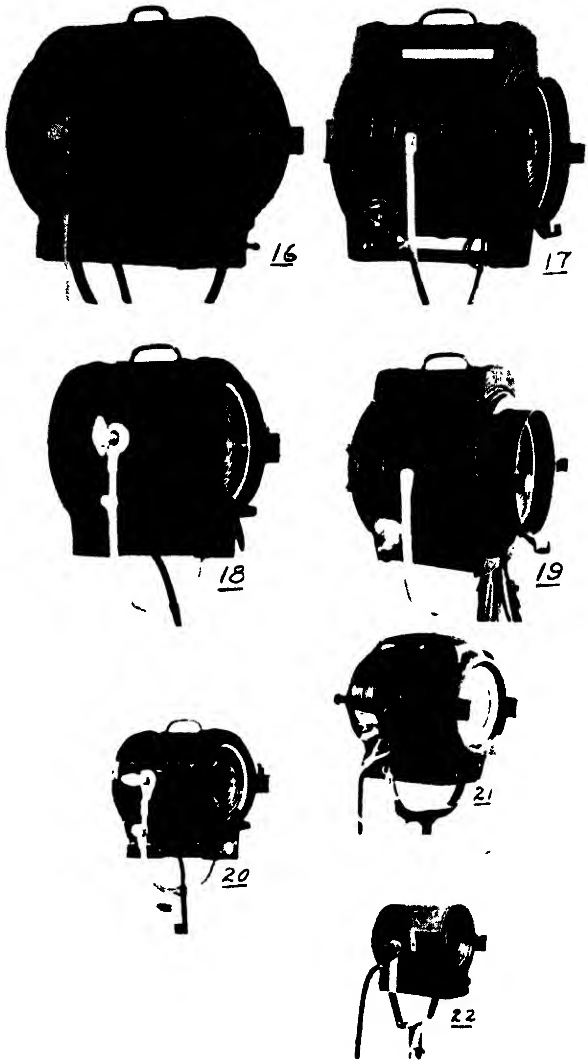


FIG. 24 (*B*). Studio spotlamps—lens types *Lamp No 16: M-R* Type *414* senior solarspot. *Lamp No 17:* B & M senior. *Lamp No. 18: M-R* Type *410* junior solarspot *Lamp No. 19:* B & M junior. *Lamp No. 20: M-R* Type *406* baby solarspot. *Lamp No. 21:* B & M baby Keg-Lite. *Lamp No. 22:* B & M Dinky Inky.

decrease in color-temperature of approximately 10°K, a decrease in light output of approximately 3 per cent, and an increase in life of approximately 6 to 12 per cent.

Following are descriptions of several types of incandescent lamps now in general use in motion picture studios.

INCANDESCENT LAMPS

Figs. 24(*A*), (*B*), and (*C*) illustrate the various incandescent lamps described in the following paragraphs.

(*10*) *M-R Type 16 Cinelite.*—A spun aluminum reflector, finished inside by wire brushing and chemical treatment, which gives it a diffusing characteristic. Used where lightness and portability are required.

(*11*) *Broadside* (*Doubles*).—Two flood-type reflectors housed in one unit, used for floor, side, and overhead lighting. One of the first incandescent units made.

(*12*) *Broadside* (*Singles*).—Similar to lamp no. 11, but accommodating only one bulb.

(*13*) *M-R Type 45 Rifle Lamp.*—Stamped metal reflector, chromium plated with rifled corrugations for diffusion. Used for general floor lighting.

(*14*) *Sky Light.*—A shallow diffuse reflector about 24 inches in diameter. Used below and above sky backings and screens, where flat, even light distribution is required.

(*15*) *Overhead Strip Lamp.*—A trough-like unit containing sockets for five 1000-watt *PS52* bulbs. Used to supply fill-in light where it is difficult to use a more bulky housing.

(*16*) *M-R Type 414 Senior Solarspot.*—A 14-inch diameter Fresnel-type lens. An Alzac spherical mirror is used at the rear of the bulb to direct the light toward the lens. Used where high-wattage units are desirable, for back-lighting, front-lighting, and side-lighting.

(*17*) *B&M Senior.*—Similar use to lamp No. 16.

(*18*) *M-R Type 410 Junior Solarspot.*—A 10-inch diameter Fresnel-type lens. An Alzac spherical mirror is used at the rear of the bulb to direct the light toward the lens. Used for back-lighting, front-lighting, and modeling within its intensity range.

(*19*) *B&M Junior.*—Similar use to lamp No. 18.

(*20*) *M-R Type 406 Baby Solarspot.*—A 6-inch diameter Fresnel-type lens. An Alzac spherical mirror is used at the rear of the bulb to direct the light toward the lens. The small size of this lamp

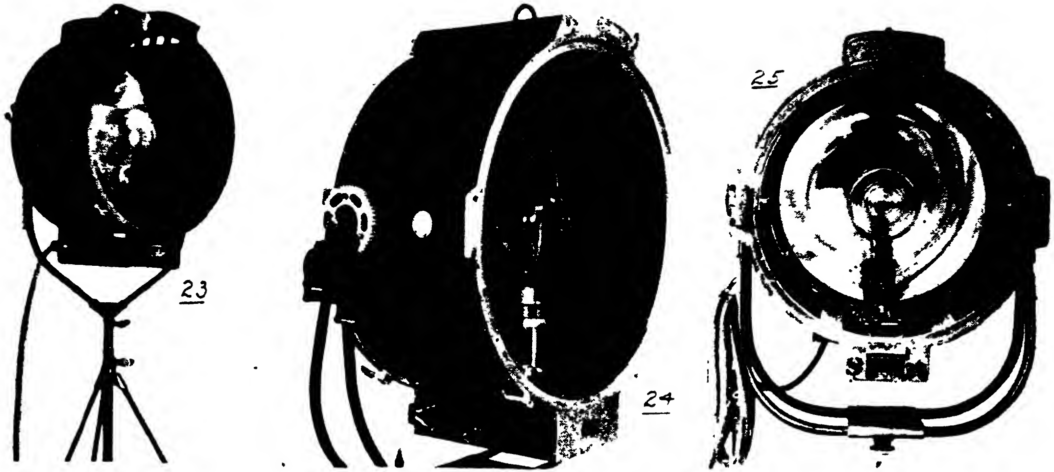


FIG. 24(*C*). Studio spotlamps—reflector types *Lamp No 23:* *M-R* Type *226* 24-inch Sunspot. *Lamp No 24:* *M-R* Type *360* 36-inch Sunspot *Lamp No 25:* *M-R* Lens Type studio spotlamp.

permits its use in places where the larger lamps can not be accommodated, particularly where it is necessary to conceal a source of high-intensity light.

(*21*) *B&M Baby Keg-Lite.*—Similar use to lamp No. 20.

(*22*) *B&M Dinky Inky.*—An extremely small Fresnel-type lens unit accommodating 100 or 150-watt bulbs. For use where high-intensity controllable light is needed at close range from a unit

TABLE III

Incandescent Lamps for Set Lighting

Lamp No.	Unit	*Degrees Beam Divergences		Bulb No. **(B & W)	Bulb No Color
		Min	Max		
10	*M-R* type *16* Cinelite	60	60	12	
11	Broadside (doubles)	90	90	11	9
12	Broadside (singles)	90	90	5	
13	*M-R* type *45* rifle lamps	60	60	10 or 11	
14	Sky light	180	180	2	2
15	Overhead strip lamp			11	
16	*M-R* type *414* senior solarspot	10	44	2	2
17	*B&M* senior	10	44	2	2
18	*M-R* type *410* junior solarspot	10	44	3	3
19	*B&M* junior	10	44	3	3
20	*M-R* type *406* baby solarspot	8	40	5–6	5–6
21	*B&M* baby Keg-Lite	8	40	5–6	5–6
22	*B&M* Dinky Inky			7 or 8	
23	*M-R* type *226* 24-inch sunspot	8	44	2	2
24	*M-R* type *360* 36-inch sunspot	12	24	1	1
25	*B&M* type *T-5* or *M-R* lens type studio spotlamp	8	40	2	2

* Approximate figures referring to usable photographic light.
** For black-and-white photography.

which may be hidden behind a pillar, mounted on the camera dolly or carried by an assistant.

(*23*) *M-R Type 226 24-Inch Sunspot.*—A 24-inch diameter glass mirror, with a spill ring that allows only projected light to leave the lamp. Used for back-lighting large sets, in which case the heads are removed from the pedestals and are mounted on parallels or platforms built at the top of the set or hung from the stage roof or ceiling.

(*24*) *M-R Type 360 36-Inch Sunspot.*—A 36-inch diameter glass mirror. Used where the highest intensity of projected light is required from an incandescent tungsten source,

TABLE IV

MOTION PICTURE STUDIO INCANDESCENT LAMPS FOR MODELING LIGHT

(Voltage—115 Volts or 120 Volts)

Bulb No.	Watts	Bulb	Base	Amps	*MP* Lamps for Black-and-White Photography			*CP* Lamps for Color Photography with Filter		
					Approx. Initial Color-Temp	Average Initial Lumens	Avg Life	Approx. Initial Color-Temp.	Average Initial Lumens	Avg Life
1	10,000	*G-96*	Mog. Bip	87.0	3380°K	327,000	75	3380°K	327,000	75
2	5,000	*T-64* or *G-64*	Mog. Bip.	43.5	3380°	165,000	75	3380°	165,000	75
3	2,000	*T-48* or *G-48*	Mog. Bip.	17.4	3275°	57,000	100	3380°	65,000	25
4	1,000	*G-48*	Mog. Bip.	8 7	3175°	25,500	100			
5	750	*T-24*	Med. Bip.	6 5	3240°	20,000	50	3380°	24,500	12
6	500	*T-20*	Med. Bip.	4 4	3210°	13,000	50	3380°	16,000	8
7	150	*T-8*	D.C. Bay.	1 3	3060°	3,300	25			
8	100	*T-8*	D C Bay	.9	2975°	1,950	50			

PHOTOGRAPHIC LAMPS FOR FLOOD AND FILL LIGHTING

Bulb No	Watts	Description	Bulb	Base	Volts	Amps	Approx. Initial Color-Temp.	Average Initial Lumens	Avg. Life
9	2,000	*CP* Movieflood	*PS-52*	Mog. Scr.	105–120	17.4	3380°K	65,000	15
10	1,500	*MP* Photographic	*PS-52*	Mog Scr.	115 or 120	13.1	3180°	37,500	250
11	1,000	*MP* Photographic	*PS-52*	Mog. Scr.	115 or 120	8.7	3130°	24,500	250
12	1,000	No. 4 Photoflood	*PS-35*	Mog. Scr.	105–120	8 7	3400°	33,500	10
13	500	No 2 Photoflood	*A-25*	Med Scr.	105–120	4 4	3400°	17,000	6
14	250	No. 1 Photoflood	*A-21*	Med. Scr	105–120	2 2	3400°	8,650	3
15	1,000	No. 4B Daylight Blue	*PS-35*	Mog Scr.	105–120	8 7	4800°*	21,800	10
16	500	No 2B Daylight Blue	*A-25*	Med. Scr.	105–120	4 4	4800°*	11,000	6
17	250	No. 1B Daylight Blue	*A-21*	Med Scr	105–120	2 2	4800°*	5,600	3

G = spherical, PS = pear-shaped, T = tubular, A = modified pear-shaped. Numbers refer to diameter in $^1/_8$ inch.
* Approximate; intended to supplement daylight.

(25) *B&M Type T-5 and M-R Lens Type Studio Spotlamp.*—A short-focus Fresnel-type lens in front of the bulb and a small fixed spherical mirror behind the bulb project light forward into the field. This, in combination with the light projected around the lens from the 24-inch reflector, gives an even, intense light. For the large mirror, either a 24-inch diameter aplanatic reflector or a 10-inch focus glass mirror is used. The aplanatic reflector produces a very even field of light. Greater penetrating power for long throws may be obtained with the parabolic glass reflector. Used for back-lighting, cross-lighting, front-lighting, and effect-lighting.

TERMS USED IN STUDIO LIGHTING PRACTICE

The terms applied to the various units of motion picture studio lighting equipment are legion and vary from studio to studio, and even from month to month. Sometimes a lamp is described by its type number alone; or by the rated current, in the case of arc spot-lights; or by the kilowatt rating of incandescent units. In some instances the mirror diameter supplies the name. Below are some commonly used terms, the "Lamp Numbers" referring to the preceding sections·

Term	Lamp No	Term	Lamp No
Broad	*2-3-11-12*	Twenty-four Inky	*23-25*
Side arc	*2-3*	5 KW	*23-25*
Sixty-five	*4*	Baby	*20-21*
Ninety	*5*	Keg	*21*
One-seventy	*6*	Junior	*18-19*
Twenty-four	*7*	Senior	*16-17*
Thirty-six	*8*	Pan or Skypan	*14*
Eighty	*9*	Doubles	*11*
Rifle	*13*	10 KW	*24*
T-5	*25*	Strip	*15*

The following are a few terms used for material and equipment associated with the use of studio lamps:

Silks. Frames equipped with china silk diffusers, hung on the fronts of lamps to diffuse the light and reduce the intensity.

Jellies.—Frames equipped with chemically treated gelatin. Used for the same purposes as silks.

Scrim.—Black gauze used in various places to reduce intensity and diffuse light.

Diverging Doors.—Strips of cylindrical glass lenses. Used on sun arcs for light diffusion.

Snouts.—Various shapes of black sheet-metal hangers. Used on the fronts of lamps to block out undesired light.

Spill Rings.—A series of sheet-metal tubes, used in front of incandescent bulbs in mirror-type lamps to block off angular rays emanating from the front surface of the bulb or filament (see photographs of lamps *23–24*).

Spot Projector.—A unit equipped with a condenser system that fits on the front of a type *170* carbon arc lamp in place of the Fresnel-type lens; used to produce a sharply defined round spot of light.

Barn Doors, Gobos, Flags, Cheese Cutters, Niggers, etc.—It is often desirable to place opaque screens at various points on a set to keep all or a part of the light from reaching certain areas or objects. These screens are painted dull black and are rectangular, square, or circular, as the occasion may require.

LAMP FILTERS FOR COLOR PHOTOGRAPHY

Carbon Arc Lamps.—Carbon arc lamps *1, 2, 3* are used for Technicolor photography without color filters. All types of high-intensity rotating arc lamps require a type *Y-1* straw gelatin filter.[4]

Incandescent Bulb Lamps.—Where incandescent bulbs are used on Technicolor photography a special blue glass *Whiterlite* filter is required along with a series of *CP*-type bulbs, which burn at a uniform color-temperature of 3380°K.[11]

REFERENCES

(*All references are to J. Soc. Mot. Pict. Eng. except where noted.*)

[1] MOON, PARRY: "Proposed Standard Solar-Radiation Curves for Engineering Use," *J. Franklin Inst.*, **230** (1940), p. 583.

[2] HANDLEY, C. W.: "The Advanced Technic of Technicolor Lighting," **XXIX** (Aug., 1937), p. 169.

[3] MOLE, P.: "New Developments in Carbon Arc Lighting," **XXII** (Jan., 1934), p. 51.

[4] RICHARDSON, E. C.: "Recent Developments in High-Intensity Arc Spot-Lamps for Motion Picture Production," **XXVIII** (Feb., 1937), p. 207.

[5] HANDLEY, C. W.: "Lighting for Technicolor Motion Pictures," **XXV** (Nov., 1935), p. 423.

[6] JOY, D. B., BOWDITCH, F. T., AND DOWNES, A. C.: "A New White-Flame Carbon Arc for Photographic Light," **XXII** (Jan., 1934), p. 58.

[7] BOWDITCH, F. T., AND DOWNES, A. C.: "The Photographic Effectiveness of Carbon Arc Studio Light-Sources," **XXV** (Nov., 1935), p. 375.

[8] BOWDITCH, F. T., AND DOWNES, A. C.: "The Radiant Energy Delivered on Motion Picture Sets from Carbon Arc Studio Light-Sources," **XXV** (Nov., 1935), p. 383.

[9] BOWDITCH, F. T., AND DOWNES, A. C.: "Spectral Distributions and Color-Temperatures of the Radiant Energy from Carbon Arcs Used in the Motion Picture Industry," **XXX** (April, 1938), p. 400.

[10] JOY, D. B., AND DOWNES, A. C.: "Characteristics of High-Intensity Arcs," **XIV** (March, 1930), p. 291.

[11] Report of the Studio Lighting Committee, **XXX** (March, 1938), p. 294.

BIBLIOGRAPHY

RICHARDSON, E. C.: "A Wide-Range Studio Spotlamp for Use with 2000-Watt Filament Globes," **XXVI** (Jan., 1936), p. 95.

Report of the Studio Lighting Committee, **XXV** (Nov., 1935), p. 432.

FARNHAM, R. E., AND WORSTELL, R. E.: "Color Quality of Light of Incandescent Lamps," **XXVII**(Sept., 1936), p. 260.

THE PARAMOUNT TRANSPARENCY PROCESS PROJECTION EQUIPMENT

FARCIOT EDOUART

Summary.—*A brief description of the evolution of the modern transparency process projection equipment, from the single-projector, 12-ft screen set-up twelve years ago, to the modern 36-ft screen for black-and-white pictures or the 36-ft screen for Technicolor, projecting 126,000 lumens of light from a triple-headed projector casting three pictures accurately superimposed upon the screen*

From an engineering viewpoint the transparency, or projected-background process of special photographic effects cinematography got off to a most unfortunate start. It was never invented, in the strict sense of the word. It was put to practical use from the very beginning, and there was no opportunity of engineering it into a technological coördination of methods and equipment.

For a number of years before the present process became a reality, many in the industry who had been specializing on what used to be called the "blue-screen process" or complementary-lighting method of "composite photography," had been thinking how valuable it would be if we could simply project a motion picture upon a translucent screen from behind the set and the actors by the ordinary black-and-white procedure, and rephotograph the screen, set, and actors together, so as to produce the illusion that the projected background was as real and as much a part of the scene as the actual foreground and actors. Three important factors were lacking: (*1*) we needed a simple, non-mechanical method of accurately synchronizing the background projector and the foreground camera shutters; (*2*) we needed negative emulsions of sufficient speed and sensitivity to enable us to record the back-projected picture; and (*3*) we needed better and faster optics, and light-sources of increased power to get a brighter image through our background screens.

Some twelve to fourteen years ago, all these things came in relatively quick succession. The advent of sound gave us a variety of simple electrical hook-ups for interlocking the camera and the projector. The newer "super-sensitive" panchromatic emulsions gave us the needed film-speed. The projection requirements of the increasingly large theaters led to improved optics and light-sources, and the further projection requirements of the wide-film flurry of eleven years ago completed the development.

We finally had what we needed and wanted; and the first production to utilize the new process effectively was Fox's *Just Imagine*. Individuals in several studios assembled various units together as well as they could, and began to make back-projection shots. That the results were successful is probably more to the credit of the skilled craftsmen who operated the equipment than to any enduring merit of the equipment itself.

Yet the many-fathered idea worked. It worked so well that the transparency or back-projection process immediately became a very vital adjunct to production. It even then began to eliminate, to a very great extent, many long location-trips, with the increased costs and hazardous delays that such trips generally involve. It minimized, for example, the need for hiring a full-size ship and, with technicians and cast aboard, cruising expensively up and down the seas in search of the correct combination of backgrounds and weather. It almost completely eliminated the technical difficulties and not infrequent dangers involved in making, by straight-forward methods, sound scenes showing our actors riding horses, automobiles, airplanes, speedboats, and the like. It afforded better control of sound recording and lighting in all these scenes. In a word, it conformed ideally to the industry's ideal of getting the best possible picture under the most completely controllable conditions, and with a minimum of time, expense, and danger.

No wonder, then, that the industry's use of the process has constantly increased. In 1930, the last year before the introduction of the process, the Paramount process department made 146 composite process shots by the earlier blue-screen method. The following year, using the projection process, this figure was more than doubled, while the cost per scene was considerably reduced. Within two years, the number was again doubled, with increased economy and greater effectiveness. And every year since, we have had to make more and more transparency shots, until now we make between

1600 and 2000 set-ups a year, and hardly a picture goes out without some of these scenes in them.

Producers and directors constantly strive for greater scope through the use of larger, and still larger, screens. When the process first began to be used, a scene inside a closed car with a screen six or eight feet wide was something to be happy about. Before long, demand forced us to find ways of using screens 12, 15, 18, and 20 feet across, not only for black-and-white but for color photography as well. When we finally succeeded in using a 24-foot screen, demands immediately arose for a 36-foot screen.

From an engineering viewpoint, this was decidedly wrong. Our equipment was not engineered for the work, and certainly the various components had not been designed to work together as a unit. We had to build our own equipment, and would usually take the best projector-head we could find and equip it with a camera-type pilot-pin movement. Some of us used Bell & Howell movements, some used Mitchells, adapting them to the service as well as we could.

It was the same thing with projection lenses, projector lamp houses, electrical control systems, and the rest. Though it was carefully and accurately made, the best equipment in any studio was only makeshift for the purpose. It was a miracle that the equipment performed as well as it did; and we were at the end of our resources to produce more light and more scope with the elements we had at hand.

The manufacturers of the component units could hardly be blamed for not producing the special equipment we so urgently wanted. The market was far too small, and the requirements far too individualized to permit even the limited volume production known in the manufacture of ordinary professional cameras and projectors. One studio preferred Bell & Howell movements for their projectors, another the Mitchell-type registration. One expert wanted a type of lamp house or lens which another condemned. The manufacturer was confused, and could not afford to produce a product of which he might sell but two or three single units.

Realizing this, a group under the sponsorship of the Academy Research Council decided to attempt to bring the industry's process specialists and the manufacturers and engineers together, to the end that they might try to set up industry-wide standards and specifications for such equipment, from which the manufacturers could conduct the necessary engineering research and build equipment

that would stand a chance of suiting the majority of the industry's transparency or process-shot requirements.

It was not an easy task. Personalities, professional suspicions, and "trade secrets" were involved. Finally we managed to get together most of the industry's leading process-shot specialists, the engineers of the firms that manufactured cameras, projectors, lenses, arc and incandescent lamp houses, and so on. At first the sessions of the committee were unproductive; no one wanted to make the first move—and nobody wanted to withdraw.

But finally, after many meetings we set up a complete basic specification representing definite requirements; auxiliary specifications, which were desirable methods of fulfilling these requirements; and accessory specifications, which indicated features that were desirable, but not indispensable. The specifications were so much beyond our immediate requirements that it seemed almost overoptimistic to hope that they could ever be completely realized.

The project was started in 1938. The specifications were approved in 1939. During 1942 the first complete sets of equipment built to these specifications were delivered, assembled, and put into service. At the Paramount Studio there are at present four of these apparatus in operation. Each such apparatus forms in itself a complete unit for conventional single head transparency projection, affording illuminating power and convenience of operation hitherto unknown. Any of these "singles" will permit us to make shots, either in black-and-white or in color, that would previously have demanded the old-style triple-head projection.

For scenes demanding even greater scope, *any* three of the new units can be combined into an extraordinarily efficient new-type triple-head assembly by simply removing them from their single bases and mounting them on our new standard triple-head base.

In this triple-head ensemble three complete projection mechanisms are used. The center unit is the key machine, and directly faces the screen; the two outer units face inward, perpendicular to the center machine, and their images are reflected to the screen by means of front-surface mirrors. The three images are accurately superimposed on the screen, and the resulting increase of screen illumination is in the neighborhood of 280 per cent. By manipulating the intensities of the three light-sources, or the densities of the three background prints, a considerable degree of control of intensity of the projected, superimposed, composite image is possible. The

superposition of the three images tends also to eliminate the graininess, which is, of course, further assisted by the use of fine-grain film-stocks in making the prints, or plates, as we call them.

Some idea of the advantages that have been gained through the triple-head technique, and the recently increased efficiency of the new-type units, may be gained from the following figures. A few years ago, when we first had need for powerful process-projection equipment for a Technicolor picture, we borrowed what was then the most powerful single projection unit in the industry, the very fine one owned by Selznick Productions. Using a six-inch $f/1.6$ Hugomeyer lens, it projected to the screen 26,000 lumens of light.

We had already developed our own first triple-head equipment—an assembly of the best units then available before the present Academy specification equipment became available. This enabled us to work successfully in black-and-white pictures with $f/2.3$ lenses on a 24-foot screen, producing about 47,000 lumens.

Today, with the new triple-head equipment, we have worked successfully on a 36-foot screen in black-and-white pictures, and on a 24-foot screen in Technicolor, with a flux of 126,000 lumens!

It would seem that this accomplishment would cover all requirements of transparency projection process work. However, so closely do the demands for greater and greater dramatic scope keep crowding on the heels of technical achievement that it has already proved inadequate. In a recent Technicolor production the problem arose of using a projected background in some very large-scale sequences showing a forest fire. Due to the requirements of story, action, and setting, a 24-ft screen-width was not sufficient. We finally used a spread of 48 feet of background-screen width! More would have been desirable, could it have been obtained.

This was probably the largest projection process set-up so far attempted. We used not one triple-head equipment, but two, projecting on adjoining screens each 24 feet wide. For one of them we employed our own triple unit, and borrowed the second from RKO. With these we achieved our shot most successfully; and inevitably the demands of forthcoming productions are already greater.

In making these shots, we had the serious problem of operating six projection heads, two Technicolor cameras, and the sound recorder, all in synchronism. The foreground set was quite large and the projectors were never less than 100 feet, and often 150 feet, from

the screen, making the total distance from the camera to the back of the projection equipment nearly 300 feet.

This emphasizes the extreme precision required in designing equipment for this service. When a single-frame motion picture image $3/4 \times 1$ inch in size is magnified to fill screens up to 27×36 feet, every physical, mechanical, and optical imperfection of the film and of the equipment is magnified at the same time. Moreover, this enormously magnified picture is at the end of an optical "lever-arm" 100 feet or more in length, and any irregularity in film registration and the like in the original negative or in the positive "plates" passing through the projector will be disproportionately enlarged on the screen. Irregularities in motion will show up strongly in comparison with the steadiness of the actual foreground pieces and action With the foreground steady, and the projected background portion of the scene unsteady, all illusion of reality would be lost in the composite scene.

The convenience and precision of operating the new units should not be overlooked. The design has been such as to provide, as nearly as possible, fool-proof, and in some instances, automatic operation. Synchronism of camera and projector, for instance, is automatically assured. Focusing is effected by remote control, from the camera position. The projector may be panned and tilted with the freedom of a camera, and with perfect precision.

While hitherto most background projectors have been at least as noisy as the average theater projector, and necessarily had to be operated only from within a bulky, sound-proof booth, the new units have been silenced to a degree comparable to that of a modern, blimped studio camera. Taking noise measurements at the usual 45-degree positions about the projector, at a distance of 6 feet, and using a meter with a 40-db ear loudness weighting characteristic, and calibrated with respect to the standard reference level of 10^{-16} watt per sq-cm, the noise level of these new machines is below 34 db.

These are not mere conveniences in operation. They add very measurably to the productive capacity of the machines. With the earlier transparency process projectors, with their less convenient controls and the greater bulk and complication due to the large sound-proof booths, one could not work very fast. The new projectors can be worked with the speed and facility of studio cameras. When making *The Forest Rangers*, with two triple-head projectors, and simultaneously projecting six plates in Technicolor, the speed of production was equal to that of shooting straight shots.

MOTION PICTURE LABORATORY PRACTICES

JAMES R. WILKINSON

Summary.—*The function of laboratory service to studio production departments and to the release distribution field is discussed. The size and scope of laboratory operations are illustrated graphically by an organization chart showing the number of sub-departments. These in turn are classified into three major divisions, namely, Control, Processing, and Maintenance. Analysis of individual department activity begins with the Control division, and emphasis is placed upon the recent trend toward more scientific approach to the problems of processing. Discussion continues with the Processing division, starting with negative development, and the processing method of each successive department is described showing the in-line flow of the work for both studio and release print operations. Problems relating to proper mechanical and electrical maintenance are also discussed.*

The motion picture laboratory is, essentially, a service organization. Its operations, while of an extremely technical nature, are not creative in any sense of the word, and possibly because of this fact its efforts are unsung and little in the way of publicity has been released from the industry relative to its activity or its contribution to motion picture entertainment. Papers on the subject have been written by G. M. Best and F. R. Gage, and by C. L. Lootens.[1]

The scope of laboratory service normally embraces the studio production division, *i. e.*, Camera, Sound, and Editorial departments; also the distribution division, including both Foreign and Domestic departments. Viewing the laboratory as a part of a major studio organization, it is considered as a single department similar to the Camera, Make-up, or Art departments. Actually the laboratory is one of the largest of the studio units, normally employing from 150 to 250 workers, and is itself divided into approximately twelve sub-departments, each with its operating foreman and a crew ranging from five to thirty workers. The specialized nature of the various laboratory operations fosters this departmentalization and, under ex-

isting conditions, it is very seldom that an overlapping of departmental activities occurs.

To assist in visualizing laboratory operating methods, Fig. 1 shows a typical organization chart and the relationship of the various departments to the supervising personnel. While the chart is typical of the average laboratory, variations can and do occur within the individual plants. Laboratory activities seem to be naturally divided into three rather separate and distinct divisions, namely, the Control division, the Productive or Processing division, and the Supporting or Servicing division. Within these divisions the departments are identified as follows:

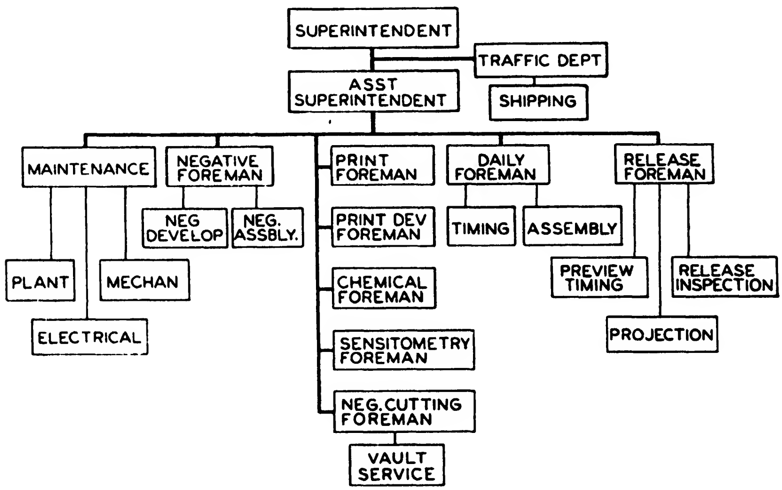


FIG. 1. Laboratory organization chart.

Control	*Processing*
Sensitometry	Negative Developing
Chemical	Negative Assembly
	Timing
	Printing
Service	Positive Developing
	Positive Daily Assembly
Mechanical Maintenance	Negative Cutting
Electrical Maintenance	Release Inspection
Shipping and Receiving	Projection

Before analyzing the various departmental functions it might be well to state briefly the nature of the work performed by the laboratory. Fundamentally it comprises the development of exposed negative, both sound and picture, and developing of positive rush prints for studio purposes; also the timing, printing, development, and shipment of completed prints for release distribution. The work for both production and distribution divisions generally passes through the plant at the same time, yet the segregation of the work for the two divisions is rather clean-cut. Each normally follows a fairly straight-

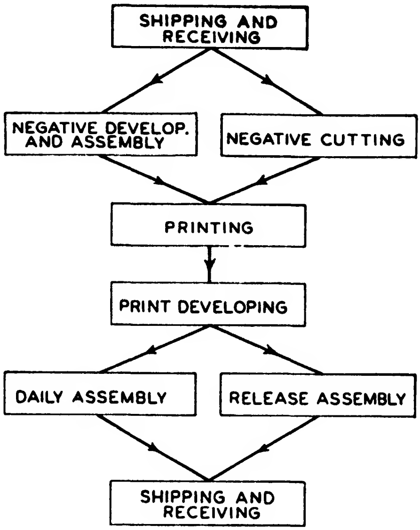


FIG. 2 Production line of daily and release print operations.

line method of procedure and the physical arrangement of departments, starting with the receiving room, is so planned to route the work through the various operations back to the point where distribution is effected, with a minimum amount of lost motion. Fig. 2 illustrates the progressive in-line flow of daily and release operations.

CONTROL DIVISION

Sensitometry Department.—Yielding first place only to the sound department, in the technical nature of its work, the laboratory has made noteworthy progress during the past few years in the more

scientific approach to its processing problems. In the control division this progress has been particularly marked. Sensitometry, actually the junior of all laboratory departments, has assumed a measure of importance undreamed of originally. It is now the function of this department, through countless tests and calculations, to establish the optimal exposure and development specifications for both negative and positive materials, whether for sound or picture purposes.

The wide increase in the use of specialized emulsion coatings, plus the intensive research program conducted prior to the general adoption of fine-grain film, has made necessary the broadening of sensitometric methods to include many tests not originally a part of classical sensitometry. This, in turn, called for the development of new types of equipment and, as a result, the dynamic analyzer together with improved photoelectric densitometers,[2] have become two of sensitometry's most useful tools. Other equipment includes the II*b* sensitometer; the microdensitometer; a sound-reproducer with suitable amplifiers, filter circuits, and volume indicator; a projection microscope; and a cathode-ray oscillograph.

It is not intended here to go into the technical details of classical sensitometry. The subject has been amply covered by D. MacKenzie and by L. A. Jones.[3] However, it is appropriate to review here some of the present duties and responsibilities of this department. A partial list of its activities include the following items:

(*1*) The testing of all emulsions, whether negative or positive, to determine their characteristics On certain emulsions the determinations of only speed and contrast are sufficient, while on others, such as are used for sound recording, dubbing prints, master positives, *etc*, a very detailed and complete analysis is made In addition to density and gamma characteristics they are checked for frequency response, distortion, printer gamma, grain size, *etc.*

(*2*) The exposure, measurement, and analysis of the II*b* gamma strips to aid the chemical department in its chemical control This applies to all processed film

(*3*) The recording of densities on all sound-track negative and the selection of the proper printing light to give a correct print density.

(*4*) The furnishing of complete reports to the sound department on daily sound-prints as well as special copies such as preview prints These include the gamma, density, and dynamic test data.

(*5*) The checking of variable-area sound-prints by the use of the cancellation or cross-modulation test,[4] by frequency response, and by projection microscope examination

(*6*) The checking of variable-density sound-prints by the use of intermodulation,[5] delta-db, frequency response, light-valve gamma, and projected gamma

tests. Fig. 3 shows typical graphs for cross-modulation and intermodulation analyses. Areas of print densities giving minimal distortion are clearly indicated.

(*7*) The checking of printer equipment for exposure, field coverage, printer gamma, light increment, contact, image shift, flicker, and noise introduced by mechanical imperfections such as worn gears, backlash, *etc.*

(*8*) The checking of developing machine equipment for 96-cycle hum, directional effect, and drying imperfections.

(*9*) Continuous collaboration with engineers of the sound department with a view to constant improvement in quality or technic.

The influence of sensitometric activity is felt throughout the laboratory, but its greatest importance lies in its relation to the chemical department through the establishment of specifications and processing tolerances that govern developing activities.

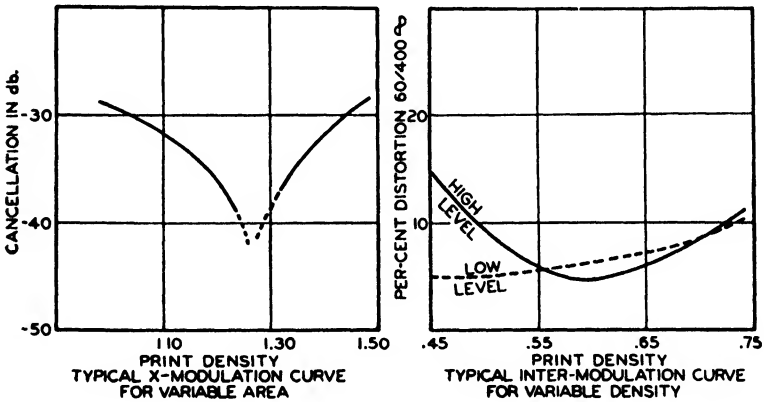


FIG. 3. Typical intermodulation and cross-modulation curves for sound-processing control.

Chemical Department.—The chemical department might readily be termed the heart of the laboratory. It is here that all processing solutions originate, and are pumped and circulated through a maze of hard-rubber piping to the various negative and positive developing machines. Fig. 4 shows a general view of tanks and equipment. In no other department has there existed a greater opportunity for scientific progress. The photographic process wherein a silver halide, which has been exposed to light, is reduced by a developing agent is one of the oldest of the arts. The action itself is a simple scientific phenomenon that is well known, yet it sets in motion a train of complex chemical reactions which, due to the volume methods of

modern technic, affect the very foundations of our work. Dr. C. E. Kenneth Mees states:[6]

> Until recently, photographic science tended to consist of a chaos of observations, some of them of real value and others of very doubtful value, with little in the way of theories to connect them properly. It is only within the last few years that fact after fact has been falling into place in an ordered network.

Just as it is the function of sensitometry to establish the complete range of specifications and tolerances for all developing procedure, so it is the responsibility of the chemical department to establish and

FIG. 4. General view of chemical department installation.

maintain chemical control over all solutions. Each developing bath, whether it be picture negative, sound negative, or positive, is designed for a specific purpose and is so compounded that it will produce the best possible quality for its particular task and do so continuously. Since film development is a continuous operation it is only logical that solution replenishment likewise be continuous and proportionate to the bath exhaustion occasioned by the footage volume. The detail of procedure and the benefits to be derived from continuous replenishment are described by H. L. Baumbach.[7]

Both developing solutions and replenishers are prepared from

chemicals that are tested in advance for their purity. These chemicals are supplied and controlled within certain tolerances which, in many instances, are more exacting than C. P. limits. Water that has been filtered, softened, and chemically analyzed is used, and is available hot or refrigerated as well as at room temperature. It has been established[8] that large volumes of footage passing through a developing solution cause reactions that necessitate control over its chemical constituents; namely, hydroquinone, metol, potassium bromide, sodium sulfite, and the alkalies that affect the *p*H. Fixing baths likewise require control for their silver content, hardening action, *p*H, stability, and rate of fixation. These controls are fundamental in nature and are based upon established chemical reactions during analyses. Standard solutions of iodine, silver nitrate, and potassium thiocyanate are used for this purpose, and *p*H measurements are determined by the Beckman *p*H meter (laboratory model) using the glass electrode. In no sense is the system of solution control dependent upon any particular film of any manufacturer.

Chemical control, due to its extreme sensitivity, makes it possible to narrow processing tolerances; once these have been established, the chemical department must maintain solutions at constant values for all important ingredients regardless of wide variation in film footage. Cleanliness is strongly emphasized and all solutions are carefully filtered to remove the insoluble by-products of development. Silver from fixing baths is reclaimed electrolytically in a continuously replenished system. In the discard the last traces are precipitated by zinc.

Occasionally sensitometric measurements will reveal a variation in emulsion characteristics of sufficient proportions to require modification of the developing solution. When this occurs, changes in concentrations are performed, and the developer is modified quickly and accurately to its new standard, thus maintaining the quality of the product at the optimal point.

The processing of tremendous volumes of footage, normally handled by a release laboratory, requires vast quantities of chemicals. Fig. 5 shows a partial view of the supply maintained. These chemicals are costly and the chemical department foreman is forced by necessity to become somewhat cost-conscious. The first consideration in every laboratory is the quality of the product. The laboratory is well able to defend this position and can point with forceful argument to the fact that chemicals are the least expensive of the many ingredients

used in the processing of pictures. However this attitude does not justify, nor does it make a virtue of, wastefulness. The alert chemical engineer observes, with no small concern, the large unused portion of chemicals in the average discarded solution. While a relatively new development, it is becoming increasingly the practice to analyze these solutions, quantitatively, for their known content. The solution can then be modified and made suitable for a different function. This is but another instance of chemical control which has now advanced to the point where solutions may be held completely within

FIG. 5. Corner of chemical storage room.

specifications at all times. The photographic element enters into consideration only when emulsion characteristics require a change in formula balance.

Exact developing formulas are of no great significance. This is due to the differences in the types of developing machines, variations in operating speeds, degree of turbulation, *etc.* However, it is possible to present what can be considered an average Hollywood formula for positive, picture negative, variable-density sound negative, and variable-area sound negative developers. The densities obtained with these formulas are obviously dependent upon (*1*) exposure, (*2*) de-

veloping time, and (*3*) developing machine characteristics. The formulas, together with the gamma range within which they operate, are as follows:

Positive

Elon	1.50 grams
Hydroquinone	3.00 grams
Sodium sulfite	40.00 grams
Potassium bromide	2.00 grams
*p*H*	10.20
Water	1.00 liter
Gamma range	2.00 to 2.75

Picture Negative

Elon	1.50 grams
Hydroquinone	2.50 grams
Sodium sulfite	75.00 grams
Potassium bromide	0.50 gram
*p*H*	8.90
Water	1.00 liter
Gamma range	0.60 to 0.70

Variable-Density Sound Negative

Elon	0.50 gram
Hydroquinone	1.00 gram
Sodium sulfite	55.00 grams
Potassium bromide	0.25 gram
*p*H*	8.90
Water	1.00 liter
Gamma range	0.35 white-light exposure, to 0.85 with ultraviolet exposure

Variable-Area Sound Negative

Elon	1.00 gram
Hydroquinone	10.50 grams
Sodium sulfite	50.00 grams
Potassium bromide	1.50 grams
*p*H*	10.20
Water	1.00 liter
Gamma range	2.75 to 3.10

* The *p*H values of the positive and variable-area sound developers are obtained with sodium carbonate. The negative picture and the variable-density sound developers are buffered solutions, and the *p*H values are obtained by borax buffered with boric acid

PROCESSING DIVISION

Negative Developing Department.—In describing the work of the departments that were grouped earlier in the processing division, it seems logical to start with negative development. It is the first of the many operations that culminate in the final release print for exhibition. Early pioneers within the industry gave much thought to the development of their negatives, and the reason for this is obvious even under changed and modern conditions. Exposed negative represents value, and it is not unusual for the negative of a single day's work on a picture to have actually cost from ten to twenty thousand dollars. Obviously, only trained personnel and operating equipment that has been perfectly maintained can be entrusted with this important task. Guesswork is out of the question and all hazard, as far as is humanly possible, must be eliminated.

Much has been written and more will be written regarding the theoretical considerations of negative development. The subject is large in scope and productive of considerable divergence of opinion. It is well known that the overall gamma or contrast of the final screen print is the product of the negative *and* the positive gamma. It therefore follows that compensation for variation in negative gamma can be obtained by an inverse variation of the contrast of the positive bath. Normal picture negatives, in Hollywood, are developed within a gamma range of 0.60 to 0.72, and positive solutions are adjusted to give satisfactory screen quality at both extremes. A negative in the low-gamma range requires very full exposure and fairly rapid development. By this procedure grain size is held to a minimum; however, emulsion speed is proportionately reduced. These conditions may be graduated progressively over the gamma range to the other extreme, where exposure is held to the minimum, development is prolonged, grain size is increased, and the emulsion speed is fully utilized or even forced. Excellent results can be and are obtained by developing to a gamma of 0.66, which is in the center of the range. In a properly balanced negative solution, development to a gamma of 0.66 permits full advantage to be taken of emulsion speed, yet development need not be extended to a point where grain size becomes objectionable. This procedure likewise has its economic advantage in that extremely high levels of illumination by the cinematographer are avoided.

There are two schools of thought regarding negative development. Certain laboratories are using what is commonly known as the test-

system, while others are developing to a constant gamma. Those using the test-system require the cameraman to make tests for the laboratory whenever a change in set-up or an important change in lighting occurs. These tests are broken out of the exposed roll of negative, properly identified, and developed in advance to a standard time. The negative developer, after examining the developed tests may, at his discretion, increase or decrease the development time on scenes that he believes could be improved by greater or lesser development. In developing to a constant gamma, the solution is controlled to give constant gamma and density at a given developing time, and all negative is developed to this standard. It is not the purpose of this paper either to acclaim or condemn these two systems or to argue their relative merits. It is sufficient to acknowledge that major studio laboratories are employing both systems at the present time with apparently satisfactory results.

Negatives of both sound and picture are developed on continuous developing machines. These machines are often identical in type, differing only in speed of operation and nature of solution. Both density and gamma specfications for sound-track negative vary over a wide range. Specifications are affected not only by the type of recording system used, *i. e.*, variable-area *vs.* variable-density, but also by variations in emulsion speed, contrast, frequency response, and distortion characteristics of the several different fine-grain recording stocks now widely used. The sound department makes the decision relative to optimal negative processing levels, and upon being notified of these specifications, the laboratory adheres to them rigidly until subsequent tests dictate a change in levels.

Prior to actual developing operations the machines are serviced and solutions are tested both analytically and by sensitometric strips. The negative has been made up into rolls of practical size for efficient machine operation, and development proceeds. On picture negative the time consumed, from the moment the film enters the developing solution until it has passed through the various stages of fixing, washing, and drying and is spooled on the take-up reel, is approximately forty-five minutes. Sound negative, being a positive type of emulsion, requires less time in the different stages of machine development, and passes through the equipment in thirty-five minutes. In addition to rigid solution control, temperature and humidity of the drying cabinets must be maintained within very close limits. Temperature normally runs 80°F and relative humidity is held at 55 per cent.

Negative Assembling Department.—Following development, the negative passes to the negative assembling department. Here the negative is broken down into individual scenes, and is carefully inspected for defects that may have been caused by the camera or the developing machine equipment. During this operation the worker has before him the camera or sound reports upon which all scene numbers have been logged. Scenes that have been selected for printing are segregated from the takes on which no print is desired. The latter are classified as "out negative," and are carefully identified and filed in vaults for possible future use. The "print" takes are assembled in numerical continuity, and a light-card is prepared for each reel. This card shows the date, the production number, all scene numbers within the reel, and the type of raw stock to be used for printing; a column is provided for future printing lights.

As this operation is completed, the assembled sound-track negative is sent to the sensitometry department, where densities are measured and the proper printing light is indicated on the light-card opposite each scene. The assembled reels of picture negative, together with their light-cards, proceed to the cinex testing room and the work of the negative assembly group is completed.

Timing. Upon arrival of the assembled negative in the cinex testing room, each scene is carefully examined and test exposures are made for timing purposes. These tests, when developed and dried by a standard developing procedure, afford the timer a strip of single-frame pictures made by a series of exposures precisely calibrated to parallel the light-increment steps of the printing machines. By visual examination of these tests over a uniformly diffused light-source of approximately 20 foot-candles, the timer selects the particular printing light which, in his judgment, will represent the best visual result on the screen. Fig. 6 shows the timer checking the cinex tests.

Frequent discussions with cameramen are valuable to the timer in order that he may understand and faithfully interpret, through the print medium, the particular type of lighting or key of photography for which the cameraman or director is striving. This work approaches the artistic field more closely than any laboratory task and demands a high degree of skill, experience, and personal judgment.

As the printing lights are selected they are indicated on the light-card opposite the appropriate scene number. Following printing and development of the prints, the timer inspects his work on the screen; and if a scene has been missed widely, corrections are made

and a reprint is ordered. Reprints are costly; thus it naturally follows that the fewer the corrections the higher becomes the timer's individual reputation.

Printing Department.—The printing department is responsible for the printing of all positive film, whether for studio use or for release distribution. Beyond the fact that these two types of work must both travel through a printing machine past an aperture, they have little in common. Production work for the studio comprises a large number of widely varying specialized requirements, while release printing

FIG. 6. The positive timer selects printer lights.

has been harnessed to mass production methods. Film for studio purposes is printed on the Bell & Howell Model *D* printer. These machines are continuous in operation and are designed for single printing, either sound or picture. Should composite prints be desired, the printing operation must be repeated, both negatives being printed to the same positive. All daily rush prints, except in rare instances, are printed on dual film.

Due to the variation in negative densities normally encountered, it is necessary to provide a wide latitude of exposure range for printing purposes. This range is divided into approximately 30 steps, each

step representing a light-increment of 10 per cent, or 0.06 in print density. A graph wherein printer-light increment is plotted against print density shows a linear characteristic. On the Model *D* machines the intensity of the light-source remains constant, and the change in exposure value is accomplished by a variable aperture which is manually operated. Their normal speed is 62 feet per minute.

The printing of release positive is a volume operation. For this work a number of the laboratories use the Bell & Howell Model *119A* printers. Fig. 7 shows a typical installation. These machines are

FIG. 7. Battery of Bell & Howell *119A* release printers.

designed to handle quantity footage. They operate at higher speed, have more automatic features, and both track and picture negatives are printed simultaneously. Their light-increment and intensity parallel the values of the Model *D* machines. They are reversible in direction, and many copies are printed by simply supplying new positive stock, while the negative itself never leaves the machine.

Each reel of release positive is accompanied through the plant by a work-card upon which each successive department logs a record of machines and personnel handling the film. This work-card originates in the printing department; and upon completion of the printing

operation, the printed positive is placed in a metal container, the card is attached, and the material passes to the developing department.

Positive Developing Department.—In the development of positive film, as in the printing operation, both studio and release work are handled simultaneously. Here, even less discrimination exists inasmuch as positive solutions are maintained at constant values and the development requirements of both types of work are identical. Segregation occurs only at the "take-off" end of the developing machine, where each type of material is routed to its proper department. The

FIG. 8(*a*). Film-developing machine, feed-in end

positive developing machine is very similar to that used for negative but, due to the volume requirements, is geared to operate at much higher speeds. Figs. 8(*a*) and (*b*) show general views of this equipment. A number of considerations affect the developing time of positive film, but broadly speaking, it ranges between $2^1/_2$ and $3^1/_2$ minutes. The complete span of the machine's operations requires about 30 minutes; and the close control of temperature and humidity, as previously mentioned in connection with negative, is likewise important to the positive development.

Following the development it is general practice to apply some type of film preservative to the prints. There are a number of film preservative processes in use, all of which are designed to protect the freshly developed emulsion surface from undue abrasion and damage as well as to lubricate the edges of the film to facilitate projection without emulsion pick-up. Various aspects of this subject are discussed in a bulletin published by the Research Council of the Academy of Motion Picture Arts and Sciences.[9]

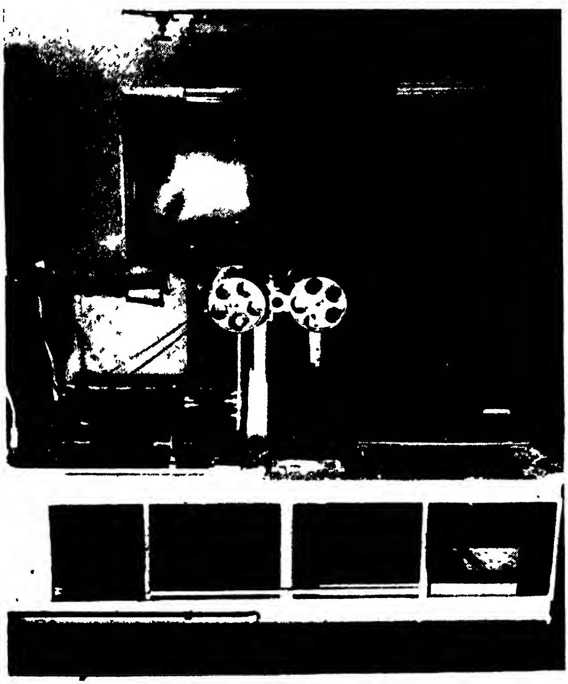


FIG. 8(*b*). Film-developing machine; take-off end.

Daily Assembling Department.—All developed prints that are to be used by the studio, both sound-track and picture, are routed from the developing machines to the daily assembling department. Here they are sorted as to picture, and the sound-track is synchronized to the picture print. Identification leaders are installed with proper "start-marks" to facilitate projector thread-up, and all prints are inspected in a sound-projection room for both sound and picture quality. Following this inspection, a log of scene numbers is prepared for each

reel, and if defects are present they are noted opposite the proper scenes. The reels are then delivered to the editorial department which arranges the screening for the producers. The material is retained in the editorial department and is used by the film editors in preparation of their first work-print.

Negative-Cutting Department.—As the preliminary editing is completed and approved, the work-print, along with an order for a first negative cut, is sent to the laboratory. From the moment that printing of daily rushes is completed until a picture has received its final negative cut, the custody of its negative is the responsibility of the negative-cutting department. Here also is handled the work of breaking down all reels into individual scenes. Proper identification is affixed to each scene showing production scene and code numbers, and all scenes are filed in large fireproof vaults. Reprints are often required by the editorial department and the filing system must be so devised that, out of the many thousands of scenes on hand, any desired scene can be located at a moment's notice.

The work-print received from the editors consists of a sound-track and a picture print; thus, on a 10-reel production there are 20 reels of negative to be cut. Negative scenes of both track and picture are brought from the vaults to the cutting room and the negative cutters proceed to cut the negative, matching each scene to the corresponding scene in the work-print. As the reel is completed the scenes are spliced together, and each scene is notched to provide for printer-light changes. Light-cards are prepared for each reel showing scene numbers, scene footages, descriptive data, and printer lights.

Due to the necessary music and sound-effects that are re-recorded into all pictures, and to editorial changes following test previews, the first negative cut on a picture is never final. It is quite normal to rematch the negative to a new and changed work-print at least once or twice before approval is given for a final negative cut. Prints prepared between the first and final negative cut are for preview, censorship, and studio library purposes. These copies afford opportunities to both the picture-timer and the sound department for printer-light balancing corrections prior to release-printing operations. The final printing lights have therefore been checked and re-checked, thus bringing the inter-scene balance for both sound and photographic values to the optimal point.

Release Assembling Department.—The printing and development of release footage having been previously described, let us pass to the

work of the release assembling department. The material has been delivered to this department from the positive developing machines and it will be recalled that each reel is accompanied by its work-card which originated in the printing department. From the information on this work-card a small paper sticker is prepared and attached to the protective leader spliced to each release reel. This sticker remains on the reel permanently, eventually accompanying it to the exchange, and provides a record of all machine numbers as well as the initials of the workers who handled the film during its processing routine. It is similar to the inspection sticker found on many factory-made garments, and provides a ready reference for checking processing records should a complaint be received from the field.

Following the installation of leaders and stickers, the reels are inspected by projection. All approved reels are sent to the spooling machine, while those wherein defects have been noted are sent to the reprint inspectors where reprints are ordered if required. As reprints are received, they are inspected and cut in, and that section of the reel is again checked before being released for spooling. After spooling, the reel is wrapped in tissue paper and placed in an individual container carefully marked in advance with the reel identifications. As the copies are completed in this manner they pass on to the shipping department for final packing and shipping.

SERVICE DIVISION

Film Shipping Department.—Upon reaching the shipping department, the completed copies are packed in fiberboard cartons. These cartons are manufactured to certain specifications of weight and strength, and conform to the requirements of The Interstate Commerce Commission and The National Board of Fire Underwriters.

Five methods of shipment are utilized by the laboratory: ocean freight, rail freight, railway express, air express, and parcel post. Packing specifications for foreign shipments vary greatly according to destination, and the shipping department must be thoroughly informed on all traffic requirements and regulations. Necessary documentation for export shipments must be provided, and it is the responsibility of the traffic manager to see that all forms are correctly executed and properly certified. Under the present stringent regulations this feature has become a considerable problem, and it is not unusual to execute and certify as many as five sets of documents to effect an export shipment. Domestic shipments to exchanges are rela-

tively simple and are normally sent by either rail freight or railway express. The distribution department is advised daily, by teletype, of all the details of each day's shipments.

Maintenance Department.—To effect an uninterrupted flow of work through the various departments, provision must be made for proper and efficient maintenance of plant and equipment. This is a major problem common to all laboratories. Much of the equipment is of complex design and of high precision, requiring the services of expert technicians for maintenance and adjustment. Electrical circuits employed likewise demand engineering knowledge of the highest order.[10] A considerable proportion of the required electrical energy must be generated as direct current, and the regulation of supply to the various power and light-source units must be accurately controlled. This control for printer-lamps is accomplished by electronic regulators, and a tolerance of 0.1 volt is maintained constantly.

Equipment of the developing and chemical departments is subject to the action of chemicals and fumes, making constant care necessary to insure efficient operation. The proper maintenance and operation of a large air conditioning installation demands a thorough understanding of refrigeration and humidity and temperature control, as well as the principles of air-washing and filtering. Cleanliness is vital to laboratory processing and these units must operate at maximum efficiency at all times.

The laboratory occupies a unique position in that a considerable portion of its equipment is not readily available for purchase in the open market. The maintenance staff must therefore be competent to design new equipment or to modify existing machines to effect the many improvements in technic that are brought to light through research and experience.

CONCLUSION

In conclusion it may be stated that the various natures of the many laboratory duties, together with departmental segregation, make the principles of organization and coördination of utmost importance to successful operation. Each department not only must function smoothly within itself but likewise must have an appreciation of the problems and efforts of the other departments, thus contributing to a well balanced efficiency in the overall task of service and research. With the importance of the technical phases of motion picture pro-

duction well established and gaining increased recognition, the laboratory takes a just pride in its contribution to this field.

REFERENCES

[1] LOOTENS, C L.: "A Modern Motion Picture Laboratory," *J. Soc. Mot. Pict Eng.*, **XXX** (April, 1938), p 363.

BEST, G. M , AND GAGE, F R : "A Modern Studio Laboratory," *J Soc Mot Pict Eng*, **XXXV** (Sept., 1940), p 294.

[2] FRAYNE, J G , AND CRANE, G R · "A Precision Integrating Densitometer," *J. Soc Mot Pict Eng*, **XXXV** (Aug , 1940), p. 184

[3] JONES, L A.: "Photographic Sensitometry," *J. Soc Mot Pict. Eng*, **XVII** (Oct , 1931), p 491, and (Nov., 1931), p 695, **XVIII** (Jan., 1932), p. 54, and (March, 1932), p 324

MACKENZIE, D : "Straight-Line and Toe Recording with the Light-Valve," *J. Soc. Mot Pict Eng*, **XVII** (Aug , 1931), p 72

[4] BAKER, J. O , AND ROBINSON, D H.: "Modulated High-Frequency Recording as a Means of Determining Conditions for Optimal Processing for Variable-Area," *J Soc Mot Pict Eng*, **XXX** (Jan., 1938), p. 3

[5] FRAYNE, J G , AND SCOVILLE, R R : "Analysis and Measurement of Distortions in Variable-Density Recording," *J. Soc Mot Pict Eng*, **XXXII** (June, 1939), p. 684

[6] MEES, C E K : "Recent Advances in the Theory of the Photographic Process," *J. Soc Mot Pict Eng*, **XXXVII** (July, 1941), p 10

[7] BAUMBACH, H L "Continuous Replenishment and Chemical Control of Developing Solutions," *J. Soc Mot Pict. Eng*, **XXXVIII** (July, 1942), p. 55.

[8] EVANS, R. M , AND HANSON, W T , JR "Chemical Analysis of an *MQ* Developer," *J Soc Mot Pict Eng*, **XXXII** (March, 1939), p 307.

BAUMBACH, H L . "The Chemical Analysis of Metol, Hydroquinone, and Bromide in a Photographic Developer," *J Soc Mot Pict Eng*, **XXXIII** (Nov., 1939), p. 517

ATKINSON, R B , AND SHANER, V C . "Chemical Analysis of Photographic Developers and Fixing Baths," *J Soc Mot Pict Eng.*, **XXXIV** (May, 1940), p. 485.

[9] Committee on Improvement in Release Quality; Report by Film Preservative Committee, F. L. Eich, Chairman, *Tech Bull*, *Res Council Acad Mot Pict Arts and Sci* (April 14, 1939).

[10] LESHING, M., INGMAN, T., AND PIER, K.: "Reduction of Development Sprocket-Hole Modulation," *J Soc Mot Pict Eng.*, **XXXVI** (May, 1941). p. 475.

WILKINSON, J. R , AND EICH, F L : "Laboratory Modification and Procedure in Connection with Fine-Grain Release Printing," *J. Soc Mot. Pict. Eng.*, **XXXVIII** (Jan., 1942), p. 56

THE CUTTING AND EDITING OF MOTION PICTURES

FREDRICK Y. SMITH

***Summary.**—The first part of this paper deals with the physical aspect of cutting and editing motion pictures—that is, the manner in which the film is physically handled in the process of assembling the various "dailies," "rushes," and other forms of film, up to the time of release.*

The second part of the paper deals with the editorial aspect—that is, the assembling of the various shots of the picture and the importance of the proper arrangement of these shots in producing the desired dramatic effects.

THE PHYSICAL ASPECT

Questions usually asked by visitors to a studio Cutting Room are, "What is a film editor?" "What does he do?" "Is a cutter a film editor?" In fact, questions like these are asked not only by laymen, but also quite often by workers of other crafts in the industry. No one thinks of asking, "What is a director, a cameraman, or a writer?" Their professions were known before motion pictures existed. Therefore, it seems to follow that whatever the skills and artistic accomplishments of the film editor—or cutter—they are specific for this medium of expression, and have grown out of motion pictures.

Webster's New International Dictionary gives the following definitions:

Cutter: One who cuts; as a stone cutter; specif.: (1) one who cuts out garments; (2) one whose work it is to cut a (specified) thing (in a specified way), as in: *amethyst cutter, machine cutter, disc cutter, gravestone cutter, timber cutter, film cutter.*

Editor: One who produces or exhibits. One who prepares the work of another for publication; one who revises, corrects, arranges, or annotates a text, document, or book.

Substituting the word *exhibition* for *publication,* and *film* for *text, document, or book,* we have a fairly simple yet accurate definition of a *Film Editor.*

This title appearing on the technical credit card of most motion pictures produced today refers to the person who assembles the scenes

after they are photographed but who is invariably referred to in the industry as the *cutter*. Whereas the term *film editor* is more indicative of the creative nature of the work, the term *cutter* seems to imply that the process is the work of a technician who performs his duties according to the standards and regulations of this profession.

This creator-technician position, as we know it now, was a child of necessity. Mass production of motion pictures demanded a person who would keep the film assembled so that when the last scenes of the picture were photographed the producer could expect an early projection of the final total results.

With the advent of sound, film cutting became a much more involved process than it was in the era of silent pictures. In those days it may have been possible to edit a picture with a work-bench, a set of rewinds, a pair of scissors, film cement, a viewing device, and a receptacle for the film.

Since the introduction of sound, film cutting has become much more technical; and before considering the artistic phase of editing, we must first become acquainted with the mechanical side of the business. This necessitates a description of the materials with which the editor works, the tools at his disposal, and the application of these tools to the materials at hand. The tools of the cutting room consist of reels, rewinds, flanges, synchronizers, scissors, film cans, bins, racks, a splicing machine and a viewing machine (moviola).

When the positive film comes from the laboratory to the cutting room, the first operation, unless it has been done already in the laboratory, is the synchronizing of the "rushes," or "dailies," which are the terms given to the scenes taken by a producing unit the previous day. A set of synchronizing leaders is prepared, and attached to the right-hand rewind apparatus. Identification marks are placed on these "sync" leaders, giving the number of the reel and stating whether it is picture or sound-track. These sync leaders are 16 feet long, the first four feet being required for threading the projector, and the next 12 feet being necessary to permit the projector to get up to full speed before showing the picture on the screen and reproducing the sound. Four feet from the beginning of each leader a frame is marked off on both picture and sound-track for the "starting mark." The frames thus marked are placed directly opposite each other on the wheels of the synchronizer and locked in position. The cutter then winds through the remaining 12 feet of leader, and marks off both pieces on the frame line of the synchronizer.

The closing of the "clappers" on the picture film and the sharp modulations on the sound-track recording the noise of the clappers provide the synchronizing cue. The picture reel is unrolled to the point of the first scene, where the synchronizing clappers are seen to come together, and the frame is marked. The point of the corresponding modulation on the sound-track film is also marked, and the two films are then placed in synchronism on the synchronizer and wound back to the start of the scene, where the films are cut. They are then fastened, by means of paper clips, to the leaders and wound on to their respective reels. The markings are made on the emulsion side of the film with red grease pencil, which can be easily wiped off with a clean, dry cloth without damaging the film. The use of carbon tetrachloride will greatly help the cleaning.

Sometimes the clapper marks occur at the end of the scene, usually under the following circumstances:

(*1*) When the position of the camera on the opening shot is such that it would be inconvenient to use the clappers.

(*2*) When it is necessary to avoid frightening the subject or impairing his acting ability by any sudden shock or noise (*e. g.*, an infant, or an animal).

The synchronizing of scenes when the clappers occur at the end is accomplished in the same way as described before. The clapper marks are framed; a foot of identifying slate footage is retained after the marked frame; and then the scene is wound back to the beginning of the scene and cut at the light flash. Where an interlocked start is used, or a synchronized fog mark is made, the procedure is the same, the fog marks being substituted for the clapper marks.

When all the scenes of one day's shooting have been thus synchronized and all the splices have been made, the "dailies" are projected for the approval of the producer, director, cameraman, and editor, after which they are sent to the numbering room. Here the film is put through a numbering machine similar to the machine that prints the key numbers on the negative. The sound-track and picture films are threaded on machines so that the number *000* will be printed at the "start" marks and every foot of film is thereafter numbered consecutively. The numbers are printed along the clear edge of the film on the side opposite the negative key numbers.

After the film has been numbered, it is delivered to the continuity room where typists make up the continuity sheets giving scene-number, description of angle and action, and the exact dialog. From the con-

tinuity department the "dailies" are returned to the cutting room, where the first and last negative key numbers of each scene, both picture and track, are written on cards which are later filed in index form. This procedure enables the assistant editor promptly to locate the trims of scenes after they are cut and filed away.

The "dailies" are now ready to be broken down. This process is accomplished with the aid of a disk or flange. The disk is placed on the rewind to the right of the operator, while the reel of action or sound to be broken down is placed on the left rewind. A ground-glass plate lighted from below is between the rewinds, so that the film may be viewed easily. The film is broken at the end of the scene, and the roll of film that has been wound upon the disk is removed from the spindle.

The film is now ready for cutting by the film editor, or it may be filed away in tins, marked with the scene number in racks or in lockers until such time as a sequence is completed and ready for a first assembly.

Omitting the editorial functions, we come to the final mechanical stages of cutting, which include the preparation and synchronization of music and additional sound-effects. These multiple sound-tracks consist of off-scene dialog, dictaphone dialog, echo or reverberant dialog, *etc.*, sounds of water lapping on a shore, croaking of frogs, chirping of crickets, motorboat sounds, *etc.* These must all be in synchronism with the picture, and built for the purpose of "dubbing" or re-recording. The splices in the sound-track are painted over with photoblack or covered with scotch tape in the form of triangles or crescents, to eliminate the noise that would otherwise occur when the sound-track is reproduced in the theater.

When the picture has been finally re-recorded and is ready for negative cutting, it is necessary for the Editor, or his assistant, to make a final check of the film, attach new standard leaders, fill in the picture with black frames and mark all negative jump-cuts unless specifically desired, and check the synchronizing numbers of each scene to the sprocket-hole, code number opposite code number. All cuts not clearly obvious to the negative cutters are plainly marked, either by pen and ink, or by scratching the film with a stylus.

This, in brief, constitutes the physical handling of film; but obviously the creative aspect of film editing has been omitted.

THE EDITORIAL ASPECT

Paul Rotha says, in part, "From the first days of film production until the present, most story-film technique to have emanated from Western studios has been based upon the fact that the camera could reproduce phenomena photographically onto sensitized celluloid, and that from the resulting negative a print could be taken and thrown in enlarged size by a projector onto a screen. In consequence, we find that more consideration is accorded the actors, scenery, and plot than the method by which they are given *screen presence*, a system of manufacture that admirably suits the departmental organization of the modern film studio. Thus the products of the scenario, together with the accommodating movements of the camera and microphone, are numerous lengths of celluloid, which merely require trimming and joining in correct sequence, according to the original scenario, for the result to be something in the nature of a film. Occasionally, where words and sounds fail to give the required lapses of time and changes of scene, ingenious camera and sound devices are introduced. It is not, of course, quite so simple as this but, in essentials, the completed film is believed to assume life and breath and meaning by the transference of acting to the screen and words to the loud speaker.

"The skill of the artist, therefore, lies in the treatment of the story, the guidance of the actors in speech and gesture, the composition of the separate scenes within the picture-frame, movements of the cameras, and the suitability of the settings; in all of which he is assisted by dialog-writers, cameramen, art-directors, make-up experts, sound-recordists, and the actors themselves, while the finished scenes are assembled in their correct order by the editing department.

"Within these limits, the story-film has followed closely in the theatrical tradition for its subject-matter; converting, as time went on, *stage* forms into *film* forms, and *stage* acting into *film* acting, according to the exacting demands of the reproducing camera and microphone.

"The opposite group of thought, however, while accepting the same elementary functions of the camera, microphone, and projector, proceeds from the belief that nothing photographed or recorded on celluloid has meaning until it comes to the cutting bench; that the primary task of film creation lies in the physical and mental stimuli that can be produced by the factor of editing. The way in which the camera is used, its many movements and angles of vision in relation

to the objects being photographed, the speed with which it reproduces actions, and the very appearance of persons and things before it are governed by the manner in which the editing is fulfilled."

To understand these words fully, let us go back to the beginning of the motion picture. Edwin S. Porter was working for the Edison Company in 1896 when that concern imported some pictures made by George Melies, a Frenchman. Porter studied these pictures very carefully and became aware of the tremendous effect such simple pictures had upon audiences. As a result an idea came to Porter that contained all the elements of motion picture making as we know it today, an idea that created a new art-form, a new mode of expression, working with new tools. It was the first process of using mechanical means to create emotional values. The idea was to try to tell a story with the new film medium by combining several shots or scenes in successive order, the story to be told not only through the action in a given scene, but also by the relation of that scene to the preceding and the following scenes, thus giving a coherent meaning to the whole.

Porter's first motion picture telling a story was *The Life of an American Fireman*. He found some stock material about fires and fire brigades and then staged such additional scenes as his plot demanded. These scenes, together with the stock shots, he assembled into a dramatic continuity that has become the pattern for all motion picture action stories since.

The very same method which Porter used in his *The Life of an American Fireman* is frequently used today. It is not uncommon for a studio having a good deal of stock material of some exciting event to assign a producer, writer, and film editor to build a story around this material. This pertains particularly to the cheaper action pictures. A picture was released last year that contained about 3000 feet of stock scenes, and the entire length was only 7200 feet.

Exactly what did Porter achieve? He discovered that real occurrences can be made dramatic by means of editing, that the art of the motion picture depends not upon the shots alone, but upon the continuity of shots. He discovered that the combination of shots into scenes gives a meaning that is not in the individual shots; and that a scene need not be taken in one shot. A long period of time in actual life can be shown on the screen in a short period of time, and *vice versa*.

The Life of an American Fireman contained a very significant in-

novation, namely, the close-up. The second scene of the picture is a close-up of a New York fire-alarm box. This was at least five years before D. W. Griffith established the close-up as an integral part of motion picture technique. Porter discovered that a film story can be made from the sum of a number of individual scenes, but D. W. Griffith developed the new technique and applied it not only to story, but also to sequence, scene, and individual shot. He found that editing enables the dramatization of the moment, that it gives perspective and interpretation. He became aware of the fact that mood and tempo could be created by the proper arrangement of scenes. He found a new technique by composing his scenes with a number of shots, each shot and scene being kept on the screen only long enough to portray the essential piece of business in its dramatic height. Without waiting for the end of a scene, he cut to the next, thus giving the whole a continuous flow and rhythm. The result, to quote from Lewis Jacobs, is that, "Not connected by time, separated in space, shots are now unified if affected by the theme. The basis of film expression has become editing, the unit of editing the shot and not the scene."

Thus the invention of editing had a great effect upon story content. The world was open, the sky the limit. Events of the moment could be put into relation to the dim past. The hero of the drama could travel to China and to the North Pole. New themes rapidly found their way onto the screen.

In *The Thread of Destiny* Griffith found another use for shots. For the first time he shot scenes not called for in the script, scenes without action, to give atmosphere and background, thus underlining the narrative and action of the story and establishing mood and motive. He introduced the extreme long shot, giving the feeling of wide space and, when the story required it, he cut to an extreme close-up, achieving a singular dramatic effect by the contrast.

In the final analysis, motion pictures are movement. Story, drama, moods, and thoughts are expressed in movement. The action is movement, the camera moves. Cutting is movement, forcing the eye of the spectator to move from one scene, one object, from one angle to another. In cutting shorter and shorter, trimming the individual shots down to the last of one essential fact, the rhythm of the movement is accelerated and the tension is led to its highest point.

To sum up Griffith's contribution to the making of motion pictures and thus to editing, Lewis Jacobs may again be quoted: "It is

that the primary tools of the screen medium are the camera and the film, rather than the actor; that the subject matter must be conceived in terms of the camera's eye and film cutting; that the unit of the film art is the shot; that manipulation of the shots builds the scene; that the continuity of scenes builds the sequence; and that the progression of sequences composes the totality of the production. Upon the composition of this interplay of shots, scenes, and sequences depend the clarity and vigor of the story." Pudovkin, the famous Russian director, states: "Editing is the foundation of film art, the process of physical integration of scenes and sequences by which the film becomes a unified entity." It follows therefore that editing becomes all important. The camera, in spite of its obvious importance, becomes subordinate to the cutting process. If necessary, a film can be made from still pictures transposed to film and assembled in changing rhythm.

The camera now has the function of an observer; an observer, however, who can see an object or an occurrence from all and every side, angle, and distance. The aim of the editing is to show the development of the scene, drawing the attention of the spectator to the details and occurrences that best represent and form the meaning one wishes to give to the scene. In doing this, the dramatic tensions are created, reinforced, or re-directed. One might compare the process to the job of an announcer at a football game. He observes the game from the most advantageous point. He does not give a detailed account of all the things happening on the field; or rather, he chooses those events that give meaning to the occasion. If the action is fast and exciting, he will hurry in his commentary, speaking in fast, short sentences that give close-up impressions. If the game is slow and uneventful, he will describe the general atmosphere, giving long-shot impressions. Just as a good announcer, by selecting the outstanding happenings—the highlights of the event—can give his listeners the impression of the entire game, so the film editor, by proper choice of his material, by using the right angles for the right piece of action, will convey to his audience the strongest dramatic interpretation of the material.

This leads to the subject of rhythm. It has been said that rhythm is the skeleton of the motion picture art, to be filled out with the flesh of content. How is rhythm built in a picture? The tempo of the action can be accelerated or slowed down in the camera, and camera movements can have rhythmic values that become apparent after editing. The rhythmic effect is formed either by the footage—that

is, by the number of frames of each shot in a sequence; by the sequence or changes of angle; by the changes in direction of movement—left to right against right to left, top to bottom against bottom to top, *etc.*, by the changes of size—long shot against close shot, *etc.;* or finally by any combination of these devices.

Ten years ago the Russian technique of cutting influenced motion picture production and turned attention to the importance of form and structure through editing. Directors, writers, and producers became montage-conscious—it was recognized that certain very strong dramatic effects could be achieved through editing and through montages. What is montage?

Montage, as the term is used in Hollywood, is a condensation of all the various ways of cutting, as mentioned before. The cutting is done partly or entirely in the optical printer, making it possible to show several scenes simultaneously. Condensation is here used not only in the technical, but also in the dramatic sense. A montage is a sequence in the abstract. It is the strongest form of dramatic expression motion pictures can give. It should, therefore, be used only when the dramatic content of the story demands it, and not, as unfortunately is often the case, when the writer does not know how to get over a lapse of time in the story.

Another important discovery was that editing releases the latent suggestive powers of an audience, thus making a series of pictures impressive, eloquent, and significant. In 1921, Kuleschov, a Soviet film director, proved this point with the following experiment. He took a medium close shot of a young man who was looking down at something. He intercut this shot once with a scene of a plate of food. While running this little sequence it was quite obvious that the young man was hungry. Then Kuleschov intercut the same scene with a shot of a dead man. Now our young man appeared afraid and seemed to have a guilty conscience. The audience was convinced that he had killed the man. Finally, the scene of the young man was intercut with a shot of a nude woman lying on a bed. Now it became apparent that the young man had strictly dishonorable intentions. The very same shot, used in three different ways, had three different meanings—a practical film demonstration of the power of suggestion.

By the same manner of suggestion, motion pictures actually have created their own symbolism and sign language, a language as vivid and changing as slang. The funnel of an ocean liner and the wake of a boat are sufficient to tell that the hero has crossed the ocean; the gavel of the judge indicates that the court is in session; a few shots of

a radio tower convince us that the news has spread to the four corners of the universe.

And now a few words about the relationship of the editor to the members of the other crafts in the industry. In the early days the editing was done by the cameraman, the director, writer, or supervisor, or any combination of them. Next to the director, and often more than he, the writer took the most prominent part in the cutting of a picture. The reason for this is quite easy to understand if one remembers that titles had to be composed to fit the material and that they had to be spaced correctly.

As pictures became longer and more elaborate, as more separate angles were shot, and as camera technique and optics improved, film editing became a specialized job. First, the cutter merely relieved the director of the tiresome job of sorting out and splicing film. But the front office soon wanted to see the assembled picture as quickly as possible. The cutter was entrusted with the first rough cut. It was soon recognized that the editor's ability to evaluate a scene was an important faculty that directors often lacked.

Eventually the editor gave the picture its final form, strengthening continuity, progression, and logic; tightening story and plot; covering up technical mistakes and bad acting. The technical knowledge of what actually can be done by arranging various pieces of film developed into a creative ability. In the old days, a personal creative relationship existed between editor and director and writer, but as the process of motion picture making became industrialized, this relationship disintegrated. Today, in most cases, a director seldom chooses his own film editor and the editor has scant opportunity to confer with the director and practically no chance to discuss story points with the writer.

In conclusion, it will be appropriate to quote from Frank Capra, one of the foremost directors of the present time and former President of the Screen Directors Guild: "The motion picture, as a creative art, peculiarly has need for many contributors, of whom the film editor is of foremost importance. Without his sympathetic understanding of theme, his sensitive appreciation for mood, his instinct for dramatic effect, and his sense of *timing* for comedy, every motion picture would suffer immeasurably."

The writer wishes to thank two members of the Society of Motion Picture Film Editors, Herman J. Kleinhenz and Walter Stern, for their coöperation and for their permission to use some of their material in this paper.

THE PROJECTION OF MOTION PICTURES

HERBERT A. STARKE

Summary.—*The final phase of motion picture production is in the theater, and the success of this phase depends upon the technique of projection and the condition of the projection equipment.*

The paper discusses in considerable detail the importance of proper maintenance, the types of light-sources, and other factors of importance to good projection.

The final phase of a motion picture production is in the theater. All the preparation and expenditure of money involved in its creation have now been reduced to so much film footage. It is now in the hands of the projectionist, with whom lies the responsibility of transferring the material to the screen, through the medium of projectors and a source of light. Motion pictures are an illusion, and are intended to convey realism to the screen.

Upon the arrival of the release print, the normal procedure in first-run theaters is a careful inspection and measurement of the entire footage. For several years, the exchanges have been doubling up the reels of features for shipment. This duty is performed for the most part by girls in the exchange. In other words, the composite film is delivered to them on spools from the laboratory; they in turn mount the *A* and *B* sections on 2000-ft reels. Our experience has been that, in many cases, this very important procedure is not properly handled. Most of the splicing is done with small mechanical splicers, which are allowed to become worn and out of alignment, with the result that inaccurate splices are made. Many of the girls engaged in this work do not realize the importance of properly blooping out splices. The splicing lacquer is allowed to become thick and slow-drying; and as re-winding proceeds, deposits from the wet application are smeared on the track over several wraps. This necessitates cleaning with a lacquer remover, and invariably the splices are removed. Under no circumstances are the shipping reels used; they are, for the most part, badly bent and unfit for use. Most of the best theaters are equipped

with cast aluminum reels, upon which the film material is mounted for the duration of the engagement.

It was the practice of first-run theaters in the early days of sound to conduct complete rehearsals before the opening of new pictures. The chief projectionist checked the volume from the auditorium, cues were made, and a general knowledge was acquired of the complete show. Today, unfortunately, this practice is not usually followed, with the result that the new shows are opened without the crew's having any accurate knowledge of the volume required. They depend solely upon booth monitoring.

Projection room routine will vary from theater to theater. Nevertheless, certain duties must be performed daily. Of great importance are the inspection and cleaning of the following units:

(*1*) Projector mechanisms

(*2*) Upper and lower magazine valve assemblies.

(*3*) Optical systems.

(*4*) Lamp houses, contacts, and all component parts

(*5*) Take-ups and belts Proper oiling with manufacturer's specified lubricant Many projectors have been ruined by inferior oils.

(*6*) Inspection of sound system.

(*7*) Inspection of generators or rectifiers. Motor switches must be replaced at regular intervals. A failure here may cause interruption of the performance.

It is important that the light from each projector be checked on the screen for intensity and color, and at the same time, image alignment should be checked. Every effort should be made to ascertain that the shutters are perfectly timed; slight bleeding that may not be observed from the projection room will cause loss of definition.

There appears to be considerable lack of showmanship today, and the absence of lighting effects is noticeable. The general procedure is to work out a schedule, the starting time is determined, and the show is on. The practice of giving away cash and other prizes in many of our *de luxe* theaters has not enhanced the production but rather has cheapened it.

The success of the presentation depends largely upon technical conditions often beyond the control of the projectionist. The equipment in many of our theaters today is inadequate, particularly with respect to the available light. Theater managers seem to be reluctant to seek proper advice when purchasing lamp equipment, and false economy often results in inadequate projection.

Light sources may be divided into three categories: (*1*) the largest theaters require condenser-type high-intensity arcs; (*2*) the intermediate theaters the *Suprex* type; (*3*) and the small theaters the 1-kw a-c or d-c types. Due to its yellow color and low intrinsic brilliancy, the low-intensity arc is being rapidly replaced by an intermediate type of non-rotating high-intensity arc having a color value approximating the white light of the rotating and non-rotating high-intensity arcs. The reflected screen light depends upon the character of the source, the optical system, and the reflectivity of the screen; and last but not least, upon the efficiency of operation. To the projectionist falls the task of coördinating these elements into a single, smoothly operating whole.

Dense prints are quite common today, and it is also becoming the practice to increase the auditorium illumination. Smoking is permitted in many theaters, tending to decrease reflectivity of the screen. The projectionist in the large theaters using the *Suprex* equipment instead of the high-intensity condenser arcs will often increase the arc wattage beyond the rated capacity of the carbon trim in an attempt to increase the brightness of the picture. He then encounters a disproportionate increase in carbon-burning rate, often beyond the feed rate of the arc control mechanism. Operation then becomes critical and efforts at manual control prevent the arc from establishing itself on a stable basis.

There has been a tendency, particularly on the West Coast, to increase the picture size without adding to the illuminations, whereupon a reduction in brightness and contrast results. Graininess is also noticeable, and all these factors lessen the value of the front rows of seats.

Operating difficulties may be encountered with the rotating high-intensity lamp, due to pitted or burned contact brushes, loose and dirty lead connections, excessive voltage at the arc. The carbon manufacturers' specifications should be rigidly followed. The lamp house should be ventilated, if possibe, with a separate exhaust fan, and dampers put into the stack in such a manner as to control the travel of air without impeding the passage of waste materials of arc combustion.

The *Suprex* and the 1-kw types of non-rotating high-intensity lamps are operated at small arc voltage and current. Hence, they are sensitive to drafts. Modern lamp houses are designed to have sufficient ventilation under ordinary conditions, but close control of

the amount of air passing through the lamp houses into the stack is essential for trouble-free operation. Abnormal draft is caused by excessive ventilation of the projection room, back-draft from certain types of rear shutters having cooling fins, and down drafts from chimneys lacking forced-draft ventilation. Excessive draft, unless very strong, does not usually cause flickering, but it does cause a movement of the arc flame, which becomes noticeable on the screen.

The non-rotating high-intensity arc, when properly burned, is almost rectangular in form, with the point of the tail flame directly above and not far behind the positive crater. If the tail flame wavers and is driven toward the front of the lamp house in an intermittent manner, excessive draft is usually indicated.

If it is not possible to control the draft with the stack damper, it may be necessary to restrict the ventilation entering the lamp house; or, if the trouble is caused by fins on the rear shutters, the fins may be removed. However, this procedure is not recommended, as the fins were installed to dissipate heat from the film and the film-trap assembly. It is suggested that the arc be protected by means of a heat-proof glass shield placed directly behind the rear shutters. It should be remembered, however, that adequate ventilation is necessary to protect the lamp house, and drafts should be restricted only to the point at which the arc will burn satisfactorily.

In order to maintain a rectangular arc shape, as described, it is necessary that the carbons be properly positioned, by raising and lowering the negative carbon until the gases are seen to escape from the top of the positive crater. For higher currents, the negative carbon tip should be slightly below the centerline of the positive, and in order to let the gases escape from the top of the crater, it may be necessary to allow the top of the positive crater to burn back as much as 0.32 inch.

Anything that disturbs the normal position or function of the arc, such as some types of carbon savers, or burning the carbons too short, may result in screen discoloration, light reduction, or change in light distribution.

The optical system of the non-rotating high-intensity lamp is designed by the manufacturer to deliver the maximum amount of light, and the arc should be operated in a given position with respect to the mirror. Moving the positive crater toward the mirror 0.10 inch from its proper distance will result in a decrease in screen illumination of approximately 40 per cent when using a 7-mm positive carbon.

In order to avoid noticeable screen color difference, the arc should be struck three or four minutes before the change-over period and the position of the image of the positive crater should be adjusted before, not after, the change-over. In many theaters where false economy prevails, projectionists are instructed never to strike the arc on the incoming projector until the last minute. With this procedure, screen results are bound to suffer.

When illumination trouble occurs it is necessary to locate it with a minimum of delay. Unfortunately, it is often difficult to determine immediately whether or not the carbons are at fault, and some projectionists keep a few trims in a dry place to be used as a check. Later if trouble occurs, carbons being currently used are checked against these reserves. If the trouble persists, one may look elsewhere for it, such as in the current supply or in the condition of the draft. Rarely are the carbons found to be at fault.

With the releasing of productions on fine-grain stock, hopes were entertained that some of the lighting problems would be lessened. Experience in this respect has been, to say the least, very disappointing. The greater brilliance and contrast are readily apparent, but the stock used so far has a tendency to buckle. The phenomenon is very curious: it comes and it goes. A print may be used for a few days without trouble; then, for no apparent reason, the picture on the screen begins to weave in and out of focus. In other words, the photographic image will be out of focus.

The modern projector is designed to be adaptable to all types of theaters. There are, however, many mechanisms now in use, particularly in circuit houses, that should have been discarded years ago Worn film-tracks and hooked sprockets are found in many of them, which are the causes of film damage in alarming proportions. Many projectionists have adopted the practice of speeding up their electric rewinds beyond the limits set by the manufacturers. This causes many fine scratches on the surface of the film, commonly called "rain," and should not be tolerated.

It is difficult to understand why so many owners and managers will not hesitate to make large expenditures on new marquees, carpets, chairs, and on the general beautifying of the auditorium, all of which can not be fully appreciated in the dark, but neglect to maintain properly the most vital part of their theater—the projection equipment. The screen is allowed to become dirty and discolored. There are many methods of so-called resurfacing; few have proved satis-

factory. The best procedure is to try to keep the surface and perforations free from dust and dirt. When discoloration does take place, the screen should be replaced. The difference in cost between an ordinary resurfacing job and a new screen is not comparatively great.

Many of the older theaters were constructed during the days of vaudeville and stage presentations. The picture was of secondary importance; consequently little if any attention was given to the planning of the projection room, which, with very few exceptions, were small and poorly ventilated. They were, in most cases, constructed high above the balcony to avoid the loss of seating space. The cost of redesigning them to present-day standards would be prohibitive.

Picture distortion and keystoning are present. Squaring the picture image by aperture-plate correction improves the general appearance, but the situation is a serious handicap to good projection. It is unfortunate that such conditions prevail in many of our first-run houses.

Notwithstanding these and many other factors, projection has for the most part improved steadily.

In 1936 the Research Council of the Academy of Motion Picture Arts and Sciences recommended the standard leader and the placing of dots in the upper right-hand corner of the composition for changeover cues. This practice was adopted by all the large producing companies, and provides a successful means of properly changing from one reel to another. Yet there are still some projectionists who deliberately deface the ends of reels with cues of their own design, such as punch marks or crosses scratched into the emulsion, all tending to impair the print and detract the audience's attention from the subject being reproduced upon the screen. True, the laboratories do not provide standard cues on many short subjects, such as newsreels and trailers, and it is necessary that some sort of cue be provided. A small inexpensive cue-marker consisting of a template and a hardened steel scriber is recommended, for scribing a small circle at the upper right-hand corner of the film image, at exactly the spot where the standard dots would appear.

Conservation is all-important today, and replacement parts will not be obtainable. It is therefore urgent that equipment should be properly checked and adjusted. There is no reason why an intermittent sprocket should not last at least three years, provided it is of the

manufacturer's specifications and the tension pads and shoes are properly adjusted. Excessive tension not only shortens the life of the sprockets, but also causes undue wear throughout the entire projector mechanism. One method of increasing the life of tension pads and shoes is to have them ground perfectly true and then chromium-plated. This also eliminates the tendency of new (or "green") film to stick while being projected.

Space does not permit a complete discussion of the many important units that tend to make up the modern projection room. Projection may be termed the bottle-neck of the industry, and there is much that can be done in the projection room to assist in placing upon the screen high-quality pictures reflecting the great amount of labor, art, and expense that went into the making of the production in the studio.

SUBJECT INDEX